One-to-One Mobile Computing

Literature Review

Prepared for Alberta Education
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Alberta
EDUCATION

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http://www.education.gov.ab.ca/technology/emerge/resources/litreview.pdf
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"The story of civilization is, in essence, about the invention and use of tools to create culture and about how societies accomplish the transference of the culture from one generation to the next. Over the thousands of years of human existence, there have been a few periods of particularly deep importance in this unfolding story. These are the seams of history when the means for creating and transferring the culture shifts from one era to another. We are in the midst of one such period."

James Bosco, Professor Emeritus, Western Michigan University[1]

[1] Bosco, James; *Tools, Culture, and Education: Past – Present – Future*; Global Summit 2006; Retrieved August 2006, <http://www.educationau.edu.au/jahia/webdav/site/myjahiasite/users/root/public/globalsummit/JBosco_GS2006.pdf>

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2. Purpose

This literature review is intended to provide practical information; lessons learned and promising practices which have been drawn from recent Kindergarten to Grade 12 (K-12) one-to-one mobile computing research reports and related articles. The information is presented in the form of answers to the following questions:

- How is one-to-one mobile computing defined?
- What research has been and is being done?
- What does the research say?
- What are the implications of this research for Alberta?

3. Executive Summary

One-to-one mobile computing facilitates collaborative teaching and learning anytime and anywhere.

Although definitions vary in the literature (see Section 3), one-to-one mobile computing describes a teaching and learning environment in which every teacher and student is provided with a wireless laptop, notebook or tablet PC for use in school or for continuous use in school and at home. The wireless computing devices are connected via broadband (e.g., SuperNet) to the Internet and equipped with software (e.g., wordprocessor, spreadsheet, database, e-mail, presentation and multimedia authoring software, etc.). Access to multimedia learning resources is also provided. The literature also defines one-to-one mobile computing in terms of how it facilitates collaborative teaching and learning anytime and anywhere.

America's Digital Schools 2006: A Five Year Forecast[2] predicts a rapid growth in 1:1 computing. This growth is not only the result of more pervasive technology and the availability of high-speed connectivity. Ample research-based evidence of the educational benefits of one-to-one mobile computing in kindergarten to grade 12 teaching and learning environments exists. Preliminary studies of large scale implementations of 1:1 wireless computing in Canada, the U.S. and Australia report the following expected and unexpected results:

- attainment of 21st century skills (e.g., critical thinking, problem-solving, team work, communications skills and ICT literacy);
- improved writing skills, academic achievement, and student attitudes and work habits;
- increases in the quantity and improvements in the quality of student work;
- increases in student motivation, engagement, interest, organization, and self-directed learning;
- improvements in student attendance and reduced student attrition;
- improved student-teacher interaction and relations;
- improvements in information and communication skills among students and teachers;
- transformation of teacher practice;
- increased teacher enthusiasm and retention;
- increased professional productivity and greater collaboration among educators;
- positive changes in the teaching and learning environment; and
- increased parental and community involvement and improved home-school communication.

(See Sections 5.1 to 5.3 for more information about the research done to date. A more complete list of the reported benefits can be found in Section 6.10.)

The results are not issue-free however. Concerns have also been reported with respect to lack of adequate professional development and/or technical support, sustainability, total cost of ownership, lack of vision, leadership, planning and/or evaluation, and/or competing educational priorities (see Section 6.11 for a more complete discussion of the issues and concerns).

Overall the research indicates that successful one-to-one computing initiatives are those that take a holistic approach with an emphasis on educational goals. Successful one-to-one mobile computing requires: leadership and commitment at all levels from those involved; thorough and long term planning; technology-infused curricula designed for the 21st century learner; current,

[2] America's Digital Schools 2006, An Education Survey of National Significance, Retrieved August 2006, <http://www.ads2006.org/main/index.php>

relevant, engaging, and curriculum-matched multimedia resources; ongoing and embedded professional development, sufficient and well-functioning hardware and software; reliable broadband connectivity; timely technical support; community support; and sustainable funding. (See Sections 6.1 to 6.9 and 6.12 for a more complete discussion of the conditions necessary for successful implementation of one-to-one mobile computing.)

Overall the research indicates that successful one-to-one computing initiatives are those that take a holistic approach with an emphasis on educational goals.

The International Society for Technology in Education identifies eleven essential conditions for implementing technology initiatives. These essential conditions include but are not limited to: 1. shared vision; 2. equitable access; 3. skilled personnel; 4. professional development; 5. technical assistance; 6. content standards and curriculum resources; 7. student-centered teaching; 8. assessment and accountability; 9. Community support; 10. support policies; and 11. external conditions.

This literature review suggests further investigation of one-to-one mobile computing is warranted and provides some of the information necessary to begin to plan additional research.

The focus of research in Alberta could be to determine how one-to-one mobile computing improves learning, promotes innovative professional practice, and supports the acquisition of 21st century skills. One-to-one mobile computing technical merits and best practices could also be identified and models for technical support, hardware and software acquisition, and sustainability could be explored.

4. How is one-to-one mobile computing defined?

"One-to-one mobile computing" or "ubiquitous computing" is defined in the education context by various authors. Some examples are quoted below.

- "One-to-one computing simply means anytime, anywhere technology for every student."[3]
- "1:1 computing [describes] an environment in which students use computing devices, such as wireless laptops or tablet PC computers in order to learn anytime and anywhere."[4]
- "… three core features common to a wide variety of initiatives [are used] as defining characteristics of one-to-one computing in the classroom: (1) providing students with use of portable laptop computers loaded with contemporary productivity software (e.g., word processing tools, spreadsheet tools, etc.), (2) enabling students to access the Internet through schools' wireless networks, and (3) a focus on using laptops to help complete academic tasks such as homework assignments, tests, and presentations."[5]
- "Mobile technology in the context of laptops for learning is defined as anytime, anywhere authentic learning."[6]
- "… one-to-one computing is essentially providing every staff member, teacher and student with a portable laptop, notebook or tablet PC for continuous use both in the classroom and at home."[7]
- "In 1:1 computing, each student is assigned a notebook or Tablet PC, connected to the Internet, and taught by a classroom teacher with a similar device."[8]
- "one-to-one computing [means] each student has full-time access to a fully-functioning computer, the Internet, software, and online research materials to work collaboratively anytime and anywhere."[9]

Generally, these definitions are characterized by references to the:

- ***degree of access to technology (i.e., anytime, anywhere);***
- ***groups who have access (e.g., students, teachers, school staff);***
- ***types of technologies involved (e.g., wireless laptops, tablet PCs, handhelds, etc.) as well as their connectivity to the Internet;***
- ***types of software (e.g., word processing) and/or multimedia learning resources used, and/or the***
- ***collaborative and authentic nature of the learning environment.***

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[3] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community* ", Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; p. 5

[4] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*; a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>; p. 3

[5] Penuel, William R; "*Implementation and Effects Of One-to-One Computing Initiatives: A Research Synthesis*"; Journal of Research on Technology in Education; March 22, 2006; p. 3

[6] Barrios, Tina, et al; *Laptops for Learning: Final Report and Recommendations of the Laptops for Learning Task Force*; March 22, 2004; Retrieved August 2006, <http://etc.usf.edu/L4L/index.html>; p. 2

[7] Underwritten by Gateway; "*One-to-One Laptop* Initiatives"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>; p. 2

[8] Underwritten by CDW-G <http://www.cdwg.com>; "*One-to-One Computing: A Revolution in Education is at Hand*"; Teachers Talk Tech Series White Paper; Received July 2006 from Stakeholder Technology Branch, Alberta Education; p. 1

Generally, these definitions are characterized by references to the:

- degree of access to technology (i.e., anytime, anywhere);
- groups who have access (e.g., students, teachers, school staff);
- types of technologies involved (e.g., wireless laptops, tablet PCs, handhelds, etc.) as well as their connectivity to the Internet;
- types of software (e.g., word processing) and/or multimedia learning resources used, and/or the
- collaborative and authentic nature of the learning environment.

The terms one-to-one mobile computing, 1:1 wireless computing, 1:1 laptop computing, or simply 1:1 computing or ubiquitous computing are used interchangeably throughout this literature review.

[9] Underwritten by Intel Corporation; *Blueprint Solutions for k-12 One-to-One Computing Intiatives - A resource for education leaders and others interested in implementing one-to-one anytime, anywhere computing in K-12 education*; Copyright 2005; Retrieved August 2006, <http://www.convergemag.com/blueprint/cd/02.PDF>; p. 1

5. What research has been or is being done?

5.1. Canada

At the time of writing, few Canadian one-to-one mobile computing initiatives were at a stage where final research results were being reported. Therefore, information about proposed initiatives, associated research, and preliminary results of initial phases are provided where available. One-to-one mobile computing initiatives in Alberta, British Columbia, New Brunswick and Quebec are highlighted.

Alberta

In December 2005, Alberta Education issued a call for proposals to pilot emerging technologies that support the delivery and enhancement of teaching, learning, and administrative systems. Proposals were invited in several areas, including mobile computing.

Wireless learning initiatives are underway in Edmonton, Calgary, Lethbridge, and Stony Plain.

Of the 16 projects being funded, three are focusing on 1:1 mobile computing. They include:

- **The Calgary Science Charter School in partnership with the Galileo Educational Network (GENA).** These partners will implement a 1:1 laptop initiative in partnership with Apple Canada to evaluate educational benefits of wireless technology and portable laptops for one hundred grades 6 to 9 students over a period of four years.
- **Edmonton Public Schools (EPSB).** EPSB will explore the effects of 1:1 laptop access on student achievement, develop a community of practice to support the use of multiple wireless technologies, and expand the use of this technology in their division. The pilot will involve 100 students and 4 teachers at the elementary level.
- **Calgary Board of Education (CBE).** CBE will investigate the impact of technology on learners in two different school settings where technology is ubiquitous and students are able to access digital tools and learning resources on-demand.

Interim results are expected to be reported in November 2006 with final reports expected in November 2007.

In addition to these initiatives, Calgary School District No. 19, Edmonton Catholic Separate School District No. 7, Lethbridge School District No. 51, Livingstone Range School Division No. 68, and Parkland School Division No. 70 had already begun implementing 1:1 mobile computing initiatives. The initiatives in Lethbridge School District and Parkland School Division were part of the Alberta Initiative for School Improvement (AISI). Published results to date are somewhat limited; however some preliminary data is available.

The quality and quantity of cross-curricular technology-based research projects is improving.

Lethbridge School District No. 51 summarized the results of their *Wireless Technologies and Middle School Teaching* project at GS Lakie Middle School on the AISI web site. They reported growth in teacher skill development and subsequent improvements in the quality and quantity of cross-curricular technology-based research projects within classrooms. Students expressed an appreciation for the advantage they feel they have in the future based on their experience. (Search the Promising Practices portion of the AISI web site at

http://education.gov.ab.ca/k_12/special/aisi/ClearingHouse/PromisingPractices/default.asp using the term "wireless" to view their complete summary).

Parkland School Division No. 70 reported that their 3-year *Laptop Classroom* project at High Park School, a project designed to create a culture where technology is a tool to enhance learning, resulted in the following reported lessons learned and effective practices:

> *Lessons learned*: Students can engage in thinking processes, tasks and problem-solving instead of being distracted by the equipment and software when technology is appropriately integrated into the curriculum on a daily basis.
>
> *Effective practices*: Effective practices that developed during the project included: 1. the use of laptops during field trips and investigations promoted decision making, file sharing, seeking expert advice via the Internet, and collaboration; 2. teachers learned to collaborate on integrated unit development, thereby increasing the variety and creativity of their lessons to better meet various student skill levels; 3. teachers learned to "fix" the easier technical problems that arise; 4. skills, knowledge, and self-confidence of teachers increased through collaborative professional development activities; and 5. parent involvement and teacher-parent communication increased through use of the homework web sites.

This project involved grade 8 and 9 students and teachers using laptops stored on portable carts. Parkland's complete project summary is available by searching the Cycle 1 AISI Project Summaries at http://education.gov.ab.ca/k_12/special/aisi/ClearingHouse/report_cycle1/default.asp using the term "laptops".

British Columbia

> *"Lab-based technology once had its place and its value. It's time is done and gone. While originally useful to teach large classes of students the rudiments of technology, labs lack the flexibility to support students in their individual learning needs."* [10]
>
> – Ron Rubadeau, Superintendent of Schools, Okanogan School District No. 23

Two one-to-one mobile computing initiatives of note in British Columbia include the *Wireless Writing Program* in Fort St. John and the recently initiated 1:1 laptop pilots in Kelowna.

Nearly half of all students reached the top two levels of writing achievement, an increase from 36% to 46% in 2005.

The *Wireless Writing Program* is a one-to-one laptop program in Fort St. John with the purpose to improve student achievement, motivation and learning skills by providing iBooks to all grades 6 and 7 students (1150 in total) as well as 37 teachers in 17 schools. Jeroski's 2005 report[11] of the *Wireless Writing Program* describes recent writing achievement results, teacher perceptions, student attitudes and perceptions, and parent views. Highlights of her report are as follows:

- Nearly half of all students reached the top two levels of achievement, an increase from 36% to 46% in 2005.
- The gender gap disappeared with 89% of boys meeting performance expectations compared to 88% of girls.

[10] Rubadeau, Ron; Technology Unplugged; Feb 3, 2005; Retrieved August 2006, <http://www.sd23.bc.ca/Superintendent/reports/TechnologyUnplugged.pdf>; p. 15

[11] Jeroski, Sharon; *Research Report: The Wireless Writing Program 2004-2005*; September 2005; Retrieved August 2006, <http://www.prn.bc.ca/wwp2005.pdf>

- Most improvements in student writing were attributable to higher scores for meaning, style and form rather than conventions which suggest that improvements were substantial, not merely the result of improved proofreading using tools such as spellcheckers.
- Although teachers recognize the positive student gains and want to extend it to the high school level, they continue to report ongoing technology problems and concerns about appropriate student use of the laptops.
- Teachers are reporting that they use a writing process approach and ensure students know the criteria that will be used to asses their writing, however, teachers rarely use the iBooks to engage students in dialogue and instructional practices including providing student choice, encouraging self-assessment, peer editing and using electronic portfolios are declining.
- Ninety percent of the teachers report using technology frequently for planning and teaching and indicate that they are integrating technology in math, science and fine arts.

Earlier results of the Fort St. John initiative were summarized by Rubadeau[12] as follows:

- student writing achievement improved over the school year,
- provincial test results were stronger for grade 7 boys however the gap between male and female students narrowed during the study,
- Aboriginal students showed particularly strong improvements in achievement, and
- most students, teachers, administrators and parents were enthusiastic about participating in the program and believed that it had a positive impact on achievement, and attitudes toward writing and learning skills.

More information about the Wireless Writing Program can be found online at http://www.prn.bc.ca/Wireless_Writing_Program.html including the 2002/03 and 2004/05 reports.

In *Technology Unplugged*[13], an Okanogan School District No. 23 report, Rubadeau summarizes data that warrants the use of wireless laptops in classrooms, describes the limits of the lab-based technologies indicative of the 1980's (e.g., alignment with instructional and curricular goals, sustainability), describes anticipated student benefits of one-to-one wireless computing, discusses his district's inventory costs and technology program, and outlines a proposed technology program, implementation schedule, and budget to 2013. Highlights of Rubadeau's report are offered below.

Generally speaking, Rubadeau's proposed technology plan for the Okanogan School District includes but is not limited to the following aspects:

- the provision of every grade 7 student and teacher with wireless technology by 2006, with successive grades being phased in to correspond with subsequent grade 7 cohorts,
- the phasing out of labs as one-to-one wireless technology becomes fully available,
- the provision of initial and ongoing professional development until all teachers achieve competency,
- district-level decision making on all technology and software decisions to ensure standard platforms, and the most efficient allocation of money and personnel, and
- the goal to ensure 100% of graduating students have state-of-the-art technology skills by 2012.

Rubadeau suggested some anticipated benefits as follows:

- improved student motivation and attitudes toward learning,

[12] Rubadeau, Ron; Technology Unplugged; Feb 3, 2005; Retrieved August 2006, <http://www.sd23.bc.ca/Superintendent/reports/TechnologyUnplugged.pdf>.
[13] Ibid.

- improved attendance,
- academic improvement especially among students at risk, students with disabilities, and gifted students,
- improved relationships between students and teachers,
- a shift towards more constructivist, inquiry-based teaching practice,
- storage of homework, encyclopedias, textbooks, and notes, and
- downloading and uploading of assignments.

This planning led to the initiation of one-to-one computing pilots in two Kelowna schools. With the aim being a seamless transition from pen and paper, to opening a laptop and starting to work, Springvalley and Rutland Middle Schools began a 1:1 computing pilot project in the 2004-05 school year. As reported in the Kelowna Daily Courier[14], the project will start at grades 7 to 9, and expand to grades 10-12 in the years to come. The numbers of laptops will double from 2000 this year, to 4000 next year. Rever, the district principal for technology and learning services, claims that after only three months into the project, he doesn't "think [he's] ever seen anything else which had such an impact". He also claims, "It will change the landscape of this district, no question about it."

New Brunswick

"Research indicates that providing dedicated computer access can have a significantly positive impact on student learning and teaching practices." [15]

– New Brunswick Department of Education

The New Brunswick Department of Education proposed a two-year (January 2004 to June 2006) action-based research project[16] to evaluate the pedagogical impact of providing dedicated notebook computer access to students and teachers. Specifically, the project was designed to assess the impact of notebooks on teaching practices, learning environment, and student motivation and achievement. Four objectives were stated for this *Dedicated Notebook Computer* project including:

- to enrich teaching and learning practices to support the skills required to succeed in the global knowledge economy,
- to improve both teacher and student ICT competencies,
- to impact positively on student motivation and achievement, and
- to increase parental and community involvement in education and lifelong learning.

New Brunswick's study, to be released in 2006, will discuss implementation processes, examine stakeholders' expectations, and assess the impact of the project on teaching and learning in the classroom.

Four schools, representing both language sectors as well as urban and rural settings, were selected to participate. The project targeted grade seven classes in the first phase and continued with the same classes at grade eight as well as the same number of grade seven classes in the same schools in the second phase. The research was conducted in partnership with both Anglophone and Francophone post-secondary research partners. The study, when completed, will include documentation of the implementation process, an examination of the expectations held by stakeholders, and an assessment of the impact of the

[14] Squire, J.P., "*A laptop on every desk*", Retrieved Wednesday, July 5th, 2006, 12:01 am, <http://KelownaDailyCourier.ca>
[15] New Brunswick Department of Education, *Call for Participation: Dedicated Notebook Computer Research Project*, May 6, 2004; Retrieved August 2006, <http://www.notesys.com/Copies/NewBrunswickDedicatedNotebook6May04.pdf>, p. 3
[16] Ibid.

project on teaching and learning in the classroom. It is anticipated that multiple approaches (e.g., surveys, interviews, and site visits involving students, teachers, administrators and parents) were used in gathering data to gain greater confidence in the findings. Early results are anticipated to be reported later this year.

Quebec

"Students say the laptops have changed the school year dramatically, helped them learn more, built stronger projects and achieved better marks." [17]

– Ronald Canuel, Director General, Eastern Townships School Board

Beaulieu, Assistant Director General, Eastern Townships School Board, announced preliminary results[18] of its *Enhanced Learning Strategy* in early December 2004, during its second year of implementation. This project involved 4500 grade 5 and 6 students using Apple iBooks. Three distinct research groups reported their preliminary findings on the integration of laptops in schools by both students and teachers, including: 1. the *Wireless Writing Project*; 2. the impact of the program on students with special needs; and 3. a technical survey highlighting areas of concern for hardware, software and infrastructure.

The majority of students taking part in the *Wireless Writing Project* showed academic improvement. For example, 90% of grade 5 students' English writing results either maintained or improved against all scoring rubrics over the four month study Eighty-two percent and eighty-four percent of students reported a preference for using the computer for writing assignments and felt that the computer made them better writers respectively.

90% of grade 5 students' English writing results were maintained or improved against all scoring rubrics over the four month study.

Recommendations resulting from the focus of the study on the significance of technology use by exceptional students included: 1. a process needs to be developed whereby schools are assisted in evaluating the need for adaptive technology; 2. administrators, professionals, teachers and support personnel working with these students need to become aware of the technology and understand the specific requirements involved; and 3. students and parents must also become aware of adaptive technologies.

Two thirds of the teachers involved indicated that they received effective training and an 18% increase in confidence regarding use of computers by teachers was noted. Ninety-nine percent of teachers rated the *Wireless Writing Project* at a 3 or above on a five-point rating scale.

Rubadeau[19] reported that this data from the Quebec experience replicates the observations made in Fort St. John. He indicated that Quebec also noted that theft, damage or malfunctions were not issues. More significantly, he noted that Quebec school superintendents (Director Generals) recognized that teachers changed classroom practice to keep pace with advances in student learning. The belief overall was that "technology reformed instruction, resulting in improved achievement."

eSchool News Online[20] recently reported that 23% of U.S. schools have implemented one-to-one computing in at least one grade compared to only 4% of schools reporting that they were planning

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[17] Eastern Townships School Board, Press Release, *Eastern Townships School Board reveals exciting preliminary research results for laptop initiative*; Dec 6, 2004, Retrieved August 2006, <http://www.etsb.qc.ca/en/EnhancedLearningStrategy/press_release/press_release_2004_12_06.pdf>

[18] Ibid; p. 1

[19] Rubadeau; p. 10

[20] eSchool News Online staff and wire reports, *1-to-1 computing on the rise in schools*; May 1, 2006; Retrieved August 2006, <http://www.eschoolnews.com/news/PFshowstory.cfm?ArticleID=6278>

1:1 computing initiatives in 2003-2004. It was also reported that 48% of district technology officers anticipate buying each student a computing device by 2011. This growth is believed to be fueled by positive results from early research, an improved fiscal climate, and new mobile computer options.

5.2. *United States (U.S.)*

Although it is reported[21,22] that as many as 19 U.S. states have implemented some form of one-to-one mobile computing, all initiatives have not been complemented by academic research, analysis, or evaluation nor are results of these initiatives easily accessible. In addition, projects initiated in the late nineteen nineties showed less promising results (i.e., little or no academic improvement, technical difficulties, inadequate hardware/software/connectivity/infrastructure, little transformation of teaching practice if not supported by appropriate professional development, etc.). These studies[23] did however make several suggestions for improvement upon which later projects were based.

This section will focus on the key findings of a recent national survey of digital schools in the U.S. as well as readily available research results from some of the most recent 1:1 mobile computing initiatives in five states, namely Florida, Indiana, Maine, Michigan, and Virginia. (Note: Section 2 of the *K-12 One-to-One Computing Handbook*[24] offers a synopsis of other one-to-one computing initiatives.)

National Survey: *America's Digital Schools 2006: A Five Year Forecast*[25]

A national survey of superintendents, curriculum consultants and technology directors from 500 U.S. school districts is to be released later this summer. This report is believed to be of significance to the planning for one-to-one mobile computing. Entitled, *America's Digital Schools 2006: A Five Year Forecast*, this study presents 8 key findings as follows:

1. Digital schools are transitioning from a desktop to a mobile world (19.4% of all student devices today are mobile and this number is expected to increase to 52.1% by 2011);
2. Ubiquitous computing is growing rapidly (i.e., each student and teacher has one Internet-connected wireless computing device for use both in the classroom and at home). As of 2006, more than 24% of school districts are in the process of transitioning to 1:1;
3. Ubiquitous computing can lead to substantial academic improvement (87% of school districts where academic results were tracked reported moderate to significant positive results);
4. A bandwidth crisis is looming and budgets for broadband may be seriously under-estimated;
5. Online learning will grow at a compound annual rate of 26% over the next five years;
6. Professional development is ranked by 65% of the superintendents as extremely important in successful 1:1 computing initiatives, yet only 16.9% of curriculum directors believe that their current PD programs are prepared to effectively support 1:1 computing initiatives;
7. Low total cost of ownership is increasingly important; and
8. The fastest growing products in the next five years include student appliances (113%), tablet computers (83%), electronic whiteboards (35%), laptop PCs (25%) and Apple laptops (24%).

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[21] Barrios, Tina, et al; see Appendix A: Review of State and National Laptop Initiatives; p. 31

[22] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>

[23] Barrios, Tina, et al; p. 31

[24] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community*"; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; Section 2.

This study also predicted a rapid growth in 1:1 computing and found that more than 87% of schools offering 1:1 computing report substantial academic improvement where results were tracked; superintendents rank low TCO (total cost of ownership) as the single most important factor in 1:1 computing implementation; and many school districts are unaware of a looming bandwidth crisis resulting from the growing number of student computers and applications.

For more information about this study, see http://www.ads2006.org/main/index.php.

Florida

> *"Students who have access to technology outside of school will find schools without access to and integration of technology into their coursework to be antiquated and irrelevant to their world."*[26]
>
> – Partnership for 21st Century Skills

As part of a state-wide advisory task force, Tina Barrios, Supervisor Instructional Technology, School District of Manatee County, summarized the results of ten laptop initiatives in Florida dating back to 1998 as well as several initiatives outside Florida (see Appendix A of *Laptops for Learning*[27]). The task force also completed a cost/benefit analysis of mobile technology and examined the equity of educational opportunities to ensure that students will have 21st century learning skills. A series of recommendations[28] for school-based and state-wide laptop initiatives resulted from their analysis of previous laptop initiatives. These recommendations are as follows:

1. ***Any laptop initiative should conform to the following nine guiding principles***:
   a. *Bridge the digital divide*: all students must have access to appropriate tools and to challenging curriculum;
   b. *Teach 21st century skills*: 21st century curriculum must be infused with information and communications skills, thinking and problem-solving skills, and interpersonal and self-directional skills;
   c. *Reform teaching methods*: teachers must create instructional in which students use higher order cognitive skills to construct meaning or knowledge, engage in disciplined inquiry, and work on products that have value beyond school;
   d. *Provide effective professional development*: successful professional development must be continuous, must provide mentors, coaches, or peer teammates to model appropriate integration strategies in actual classrooms, and must give teachers performance feedback as well as hold them accountable for implementing the strategies;

   Professional development must be continuous and provide mentors, coaches or peer teammates.

   e. *Prepare pre-service teachers for the 21st century classroom*: pre-service teachers must experience good technology integration models in all pre-service classes, have access to laptop computers for all coursework and field experiences, and have opportunities to teach in a 1:1 environment;
   f. *Provide rich multimedia resources*: students and teachers must have access to rich multimedia resources;

[25] America's Digital Schools 2006, An Education Survey of National Significance, Retrieved August 2006, <http://www.ads2006.org/main/index.php>
[26] Barrios, Tina, et al ; p. 5
[27] Barrios, Tina, et al; p. 31
[28] Ibid; p. 27

g. *Provide the appropriate tools to all students and teachers*: laptop hardware and software must be sufficient to allow students to be creators of content and must be available to use as a cognitive tool wherever and whenever the student is working;

h. *Provide adequate technical support*: technical support procedures and planning must be adequate to prevent disruptions in laptop availability and support should be handled at the lowest level practical; and finally

i. *Assess 21st century skills*: students should be given the opportunity to demonstrate 21st century skills through the use of technology-infused, authentic assessments that are more integrated with instruction.

2. ***School-site projects should have the following eight elements***:

a. laptop computers should have the following minimum characteristics: wireless connectivity; adequate battery life for school use; FireWire (IEEE 1394); USB;

b. laptops should be equipped with word processor, graphic organizer, spreadsheet, multimedia authoring, video and sound production, web browser with links to state curriculum resources, e-mail, messaging and conferencing capabilities subject to school-site control;

c. teacher and student machines should match with the addition of links to teacher training resources on teacher machines;

Students must have equitable home and school access.

d. all teachers and administrators should be provided with professional development related to 21st century skills, implementation and assessment using technology and integration of technology into the teaching of basic skills and content;

e. students must have equitable home and school access;

f. a project must NOT provide an environment of learning with technology for some students, while limiting other students to learning without technology;

g. laptop use must be integral to all subject areas; and

h. technical support plans should result in minimal technology availability disruptions.

3. ***State-wide projects should have the following five elements***:

a. a team comprised of academics from state universities tasked with designing a rigorous, scientifically-based research initiative;

b. a coordinated and supported pre-service program with at least one state teachers' college;

c. an advisory board of educators, business and community leaders, parents and experts tasked with developing a long-term sustainability plan for a state-wide laptop initiative;

d. a centre of academic excellence which will administer the initiative; and

e. the coordination and funding of free online multimedia repositories to support student learning.

In an introductory letter[29] to the commissioner, Barrios strongly recommends that Florida initiate a measured implementation of mobile laptop computing, stating that, "*Many of our districts are ready for such an initiative and a statewide coordination of this project will allow for valuable research to guide future decision-making. The costs of a properly implemented demonstration project are manageable and the benefits innumerable.*"

Probably the most thorough report of its kind, Barrios's *Laptops for Learning* report also provides valuable information on national educational technology standards, 21st century skills, technology

[29] Ibid, p. 2

readiness survey results, teacher survey results regarding use of laptops, software to support project-based learning, and a recommended research direction.

Indiana

"Teachers – even the ones who were reluctant at first – really started to see how this transformed the kids, so they made the effort to make one-to-one work." [30]

– District Administrator, Crawfordsville Community School Corporation

From 1988 to 2000, Indiana pioneered ubiquitous computing with its *Buddy Project*, which placed computers in the homes and schools of 4th, 5th, and 6th graders in select schools. This project received legislative support because it was believed that it would help build a high-tech workforce and extend the state's telecommunications network by increasing demand.

This project was reinvented a decade later based on evaluative results of its three educational aims: enhancement of students' higher-level thinking through the use of technological tools; increased parental involvement in the education of their children; and the establishment of a foundation for life-long learning. *Buddy*^{2}, as it is called, continues to emphasize home and school computers, but has shifted the focus from the technologies themselves to the effective uses of technology. They are examining how best to augment sound methodologies for learning and thereby improve academic achievement, specifically in writing. The program provides resources and professional development that enables teachers to engage students in high-quality, authentic writing processes.

Most recently, the Indiana Department of Education launched a third ubiquitous computing program focused on literacy at the high school level. This *Tech-Know-Build*[31] program is currently underway, with research results expected soon. It is hoped that this program will identify affordable models for one-to-one computing at the high school level.

Findings reported from four schools in which Buddy was implemented included:

- A significant improvement in children's writing occurred;
- Improvements in mathematics were limited and did not improve student achievement;
- Effective staff development lead to substantial teacher improvement;
- Home-school connections were established and strengthened;
- Parents, teachers, and administrators believed that participation in the project is preparing Indiana's children for the workforce of the future;
- Other school reform efforts that teachers and administrators had chosen for their particular schools were facilitated through the project (no specifics were cited);
- Parents and families who would not otherwise have had access, were able to use the computers and telecommunications provided by the project;
- Student self-confidence improved, including those who are learning disabled, lack confidence, or who would not succeed easily in regular classrooms;
- The project brought families together to work on and communicate about the computer and its value for learning; and
- Students and their families felt they could participate more in state governance as a result of their participation in the project.

Deeper cross-disciplinary knowledge and 21st century skill development was observed by 100% of the teachers interviewed.

[30] Lemke, Cheryl; Martin, Crystal; One-to-One Computing in Indiana: A State P 6, <http://www.metiri.com/NSF-Study/INProfile.pdf>

[31] Ibid, p.

One hundred percent of the educators interviewed cited the following observations:

- Increased student and teacher engagement;
- Deeper, cross-disciplinary knowledge;
- 21st century skill development (particularly higher order thinking and problem solving; use of real-world tools; collaboration; technology and information literacy);
- Improved academic achievement (as evidenced by improved grades – especially in writing); and
- Improved attendance.

Unintended results reported by Indiana included:

- Improvement in student-teacher relations;
- Increased involvement from parents and community members with students; and
- Heightened enthusiasm from teachers.

Remaining challenges include:

- Sustainability;
- Additional on-site technical support;
- Ongoing and just-in-time professional development; and
- Focusing students on educational tasks during the school day.

The complete Indiana profile is available online at http://www.metiri.com/NSF-Study/INProfile.pdf

Maine

"One-to-one computer access changes everything. But let me make this crystal clear: This is not about technology or software, it is about teaching kids."[32]
– Bette Manchester, Director of Special Projects, Maine Learning Technology Initiative

Davies[33] (2004) studied a one-to-one, high-speed, wireless, laptop computing environment in Maine to identify what assessment looks like in these environments and to further support the conversation of practitioners and researchers concerning how assessment supports learning in one-to-one computing environments. This qualitative study involved one grade 7 classroom using Apple iBooks in a small community in eastern Maine during the first year of a two-year implementation beginning in September 2002.

Maine's wireless learning initiative was possible due to legislative support, technological expertise, high-speed connectivity, a commitment to student success, collaboration with vendors and long-term planning.

The classroom Davies studied was part of the much larger initiative, the *Maine Learning Technology Initiative* (MLTI), involving nine classrooms and over 17 000 computers. MLTI was possible due to legislative support, technological expertise and experience, high speed connectivity in all schools, collaboration with Apple and its partners, and a commitment by participants to student success and long-term planning. Initial expected returns included: increased economic viability for graduates and for the state; high academic achievement; and digital equity. Unanticipated results included lower levels of teacher skepticism, improved parent-student communication, and students

[32] Lemke, Cheryl; Martin, Crystal; *One-to-One Computing in Maine: A State Profile*; December 15, 2003; Retrieved August 2006, <http://www.metiri.com/NSF-Study/ME-Profile.pdf>
[33] Davies, Anne; *"Finding Proof of Learning in a One-to-One Computing Classroom"*; April 2004; Connections Publishing

becoming respectful, responsible "ambassadors" of the program. Sustainability, the rate of capacity building among educators, and the ability of the state to retain students in "new economy" jobs remain challenges for the program as a whole. The complete MLTI profile is available online at http://www.metiri.com/NSF-Study/ME-Profile.pdf.

Davies' study analyzed structured and unstructured observations, one-to-one and e-mail interviews, and collections of evidence of student learning (digital and non-digital samples). Her conclusions, findings and recommendations are summarized in *Report at a Glance: Finding Proof of Learning in a One-to-One Computing Classroom*, (April 2004) which accompanies the full final report. Her findings and recommendations for continued implementation are outlined below:

Davies summarized her findings within five categories:

1. The Learners: Preparing for Success

   In the first category she describes how the learner is changing in terms of how they go about their learning, what they are learning and their personal context for learning. For example, students have more choice, opportunity and flexibility within the one-to-one, high-speed, wireless computing classroom. They also have access to current, relevant content and "experts" and their ability to access and present their learning in a variety of ways is improving. Students are more engaged, attend more regularly and report pride in their accomplishments.

2. The Learning Community: Access for All

   In the second category, Davies describes other changes including the way students learn and with whom they are learning. For example, she states that students are completing work faster and easier, are more willing to make mistakes because they easily corrected, and they are producing a greater range of work with better quality. They are more willing to help each other, interact more frequently and in different ways with their teachers, and assume differing roles in their learning.

3. Feedback: Monitoring for Quality

   The third category of findings is described in terms of changes in the way students think about their learning, in their interactions with others while they are learning, in what kind of student work matters, and in the teaching context. For example, students seek more feedback more frequently from more sources and use this to guide their learning. This results in not only better quality but also better self-assessment. Students and teachers are collaborating more in project-based learning environments.

4. Proof: Evidence of Student Learning

   In the fourth category, Davies highlights changes observed in the kind, quality, and quantity of evidence of student learning as well as in the ways they show proof of their learning. For example, students are taking more responsibility for and providing more evidence of their learning in many different ways that often go beyond test results. Students are also asking themselves 'what do I need to know?' and 'how will I prove I know it?' She also indicates that external accountability measures represent a smaller percentage of the evidence that before.

5. Accounting for Learning

   In the fifth and final category, Davies summarizes the problems accounting for individual student learning using current systems of reporting. These problems arise because current systems of reporting do not typically allow for the degree of student involvement in assessment that typifies one-to-one, high-speed, wireless computing classrooms. And, external assessments are limited in terms of what they are able to assess. In other words,

external assessments, which have typically been designed for a different purpose, do not account for the range of learning occurring in these environments.

In subsequent phases of this project, Davies recommended that emerging hardware and software needs in support of student and adult learning should continue to be met, that adult learning should continue to be supported, that the principal and technology coordinator should continue to work to actively remove barriers, and finally, that quantitative and qualitative research of the changing teaching and learning context should continue to be supported.

Silvernail's[34] study explored how the laptops were used, what impacts the laptops had on teachers and students, and what obstacles schools, teachers and students encountered in implementing the Maine initiative. Silvernail reached the following conclusions:

- Teachers reported using the laptops for developing lesson plans and conducting research for lesson plans and instruction. Students used them to conduct research and complete assignments. Use level by both teachers and students increased over time.
- Teachers and students reported improvements in the quality of students' work, increases in the amount they learned, increased understanding of what they were learning.
- Students were more motivated to learn and more engaged in the learning process. Interaction between teachers, and students and student and students increased substantially.
- The obstacles encountered by teachers included technical problems, lack of technical support, insufficient professional development, and lack of time to explore and learn more about uses of the laptops. School districts reported increased expenses implementing the program in their middle schools.
- Factors contributing to greater success in some schools was believed to be due to the presence of "champions" who demonstrated strong leadership, teacher involvement from the beginning, teachers supported in professional development activities, technology support provided by technology coordinators and student technology support teams, and students being allowed to take their laptops home.

Additional results from another study of a laptop program in Maine were reported in the March 1, 2004 issue of eSchool News online as follows: "*In Maine, educators at the Piscataquis Community High School (PCHS) in the rural community of Guilford are touting the results of a survey released last month, which demonstrates that laptops can have a significant positive impact on learning, especially for at-risk and traditionally low-achieving students.*"

This study involved 285 grades 9 to 12 students who were given laptops for use at home and school. Seventy-nine percent of the students felt lessons were more interesting. Sixty-four percent of teachers felt that student achievement in their classes had improved since the program began and 70% believed that student-teacher interaction improved, especially among those students defined as "at-risk" or "low-achieving" (see http://www.eschoolnews.com/news/showstory.cfm?ArticleID=4910 for the complete article). This study led to the previously described MLTI.

Michigan

"Usually such overwhelmingly positive results like this aren't seen for three or four years out. Clearly, our 1:1 computing program is doing what it is designed to do for our school children – enhance student learning and achievement in core academic subjects."[35]

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[34] Silvernail, David, Lane, Dawn; *The Impact of Maine's One-to-One Laptop Program on Middle School Teachers and Students: Phase One Summary Evidence*; Maine Education Policy Research Institute; February 2004 Retrieved August 2006, < http://mainegov-images.informe.org/mlte/articles/research/MLTIPhaseOneEvaluationReport2004.pdf#search=%22David%20Silvernail%22>

[35] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005

— Bruce Montgomery, Director, Michigan's Freedom to Learn Project

In 2003, Michigan launched the *Freedom to Learn* (FTL) project[36]. The goals were to increase student achievement, empower thoughtful teachers, increase parent involvement, and prepare students for the 21st century workforce by providing laptops to every sixth grader across the state. Now in its third year, nearly 20,928 students and 1,193 teachers in 188 buildings across 95 school districts are equipped with laptops.

Increased student achievement in math and reading as measured by the Michigan Education Assessment Program (MEAP) was cited. For example:

- Bendle Middle School – Reading proficiency scores increased from 29 percent to 41 percent for seventh graders and from 31 percent to 63 percent for eighth graders.
- Leland Middle School – In 2004, 53 percent of the students were proficient in MEAP writing. In 2005, 87 percent were proficient—a jump of 34 percentage points.
- Eastern Upper Peninsula ISD – Student proficiency on standardized tests has increased from 68 percent to 80 percent in science and from 57 percent to 67 percent in math just one year.
- Flint School District – Seventh grade reading scores in the district jumped from 29 percent to 41 percent, and eighth grade math scores increased from 31 percent to 63 percent.

Seventh grade reading scores jumped from 29 to 41 percent, while math scores increased from 31 to 63 % as measured by the Michigan Education Assessment Program.

For more details on the MEAP test results, see http://www.michigan.gov/mde/0,1607,7-140-22709_31168_40135---,00.html.

Some of the unexpected consequences reported include:

- *Teacher Enthusiasm and Retention are on the Rise* – Teachers, administrators, and technology coordinators reported high levels of enthusiasm for one-to-one computing. This is believed to be due, in part, to proper professional development (focused on both technology proficiency and integration), administrator buy-in and sufficient levels of just-in-time technical support.
- *Parents are Becoming More Involved in Student Learning* – Teachers and administrators reported that communication with families has improved, and that parents seem to be taking more of an interest in student learning.
- *Students are Caring for the Technology* – As reported by their teachers, Michigan students appear to be adapting to this new learning environment as well as demonstrating responsibility and care for the technology.

The complete Michigan profile is available online at http://www.metiri.com/NSF-Study/MIProfile.pdf.

Virginia

"With one-to-one in place, kids are collaborating, solving problems, doing research, and actually constructing knowledge. It's like nothing we've seen before to this degree."

– Superintendent, Henrico County Public Schools

CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>

[36] Lemke, Cheryl; Martin, Crystal; One-to-One Computing in Michigan: A State Profile; April 7, 2004; Retrieved August 2006, <http://www.metiri.com/NSF-Study/MIProfile.pdf>

Virginia's Henrico and Henry school divisions are reported to be national leaders in ubiquitous laptop computing initiatives[37]. Strongly supported by the state legislature, these pilot programs are flourishing and have led to the development of a *State Technology Policy* and connectivity goals within the State Technology Plan (http://www.pen.k12.va.us/VDOE/Technology/plan2003-09.pdf). Although Commonwealth budget shortfalls have meant that progress toward ubiquitous computing is slower than desired, progress continues because of the close tie between the *Standards of Learning* (which include specific computer/technology standards for grades 5, 8 and 12) and technology infrastructure. Fourty-five schools in two districts involving 37,000 students and teachers are currently using Apple iBooks.

Expected returns on investment into laptop computing by Henrico and Henry school divisions included:

- improving academic achievement (Standards of Learning (SOL) scores),
- preparing 21st century students for the real world/economically viable communities,
- improving teaching and learning, and
- closing the digital divide.

By dedicating between 4 and 5% of its operating budget over 10 years, Henrico County pursued the one-to-one initiative in their middle and high schools. Their goals were to create more student access to technology and improve learning skills as well as to achieve better returns on technology investment because limited computer lab time was inhibiting student access to technology. High school reform was the initial goal that fueled the initiative. Unanticipated results have included increased teacher enthusiasm, retention and recruitment, and increased involvement and technology literacy among parents.

Students' state-based Standard of Learning scores improved by 20% during the first year of Henry County's laptop program.

Henry County focused on improving test scores of its grade 4 to 12 students and reducing the digital divide in its community by providing a combination of one-to-one computing in some grades and classroom sets of Apple iBooks to be shared in other grades. Network accounts were provided to students who either had their own technology at home or had signed out a laptop. A parent resource centre was set up in a local mall where parents were given access to the technology. Students' scores improved by 20% on state SOL tests during the first year of the district's laptop program. It was also reported that there is a sense that the intangible results of one-to-one computing are just as important as the tangible results. For example, participants feel that the project has created a new image for the community and a new pride among its rural citizens.

The complete Virginia profile is available online at http://www.metiri.com/NSF-Study/VAProfile.pdf.

5.3. Australia

An extensive collection[38] of research, reflections, projects, and curriculum strategies has been compiled by the Department of Education, Western Australia on the *Notebooks for Students 1:1* web page at http://www.det.wa.edu.au/education/cmis/eval/curriculum/ict/notebooks/. This collection demonstrates the investment that Australia is making in 1:1 mobile computing. An example of one article is listed below with a brief summary of the author's findings.

[37] Lemke, Cheryl, Martin, Crystal, *One-to-One Computing in Virginia: A State Profile*; May 12, 2004; Retrieved August 2006, <http://www.metiri.com/NSF-Study/VAProfile.pdf>

[38] Department of Education and Training, Government of Western Australia, Resourcing the Curriculum>>ICT in the Curriculum>>Notebooks 1:1; Retrieved August 2006, <http://www.det.wa.edu.au/education/cmis/eval/curriculum/ict/notebooks/>

Fisher and Stolarchuk[39] looked at the effectiveness of notebook computers in grades 8 and 9 science classrooms and noted that "*those laptop science classrooms characterized by opportunities for individual students to interact with the teacher and an emphasis on the skills and processes of inquiry best promoted positive students' attitudes to science.*" Effectiveness was determined in terms of students' attitudinal and achievement outcomes and their perceptions of science classroom environment. Attitudes were assessed using a Test of Science-Related Attitudes (TOSRA) instrument, achievement was measured using a Test of Enquiry Skills (TOES) instrument, and perceptions of the science classroom environment were assessed using the Science Classroom Environment Survey (SCES). These instruments were administered to 433 laptop and 430 non-laptop students in 14 independent schools across four Australian states. Descriptive statistics confirmed the reliability and validity of the SCES for science laptop classroom research. Qualitative data, collected by interviewing students and teachers in two of the fourteen schools, confirmed and offered explanations for the quantitative findings.

[39] Fisher, Darrell; Stolarchuk Ed; *The effect of using laptop computers on achievement, attitude to science and classroom environment in science*; Curtin University of Technology and St Hilda's School, Southport Queensland, 1998, Retrieved August 2006, <http://www.waier.org.au/forums/1998/fisher.html>

6. What does the research say?

Overall the research indicates that successful one-to-one computing initiatives are those that take a holistic approach with an emphasis on educational goals. Successful one-to-one mobile computing requires: leadership and commitment at all levels from those involved; thorough and long term planning; technology-infused curricula designed for the 21st century learner; current, relevant, engaging, and curriculum-matched multimedia resources; ongoing and embedded professional development, sufficient and well-functioning hardware and software; reliable broadband connectivity; timely technical support; community support; and sufficient funding. These requirements for success are described below with references to corresponding literature.

6.1. Leadership and Commitment

"Implementing a one-to-one initiative requires extensive planning, goal setting, systemic change, building a school system, policy development, ongoing communication, and especially a visionary leader to champion the cause."[40]

Moulton[41] sums it up when he states that a, "*key component of a successful implementation of one-to-one laptop computers is leadership in many forms.*" He describes how leadership teams in Maine, comprised of school principals, librarians, technology coordinators, and teacher leaders, meet regionally twice each year to share their perspectives and learn from one another. Every member of the leadership team has a role to play. For example, the principal sets the educational tone – the school-wide vision of the purposeful use of technology in support of rich learning opportunities. The teacher monitors the pulse of the classroom and acts as its voice when he or she passes information to and from the team.

Moulton also recognizes that effective leadership in a one-to-one computing environment may require support, especially for new principals or principals for whom one-to-one computing is unfamiliar. A document entitled, "*Suggestions for a Principal Who is New to the Maine Learning Technology Initiative*"[42] was developed to provide some of the needed support. This document outlines critical components toward effectively implementing one-to-one computing (e.g., vision and goal setting, leadership, professional development, technical support, and procedures and policies) and explains the principal's role including some questions that should be asked. The document also points to an annotated list of additional supporting resources for each strategic area (see http://MaineLearns.org).

Leadership in many forms is a key component of successful implementation of one-to-one mobile computing.

The need for leadership is echoed in Section 3: Leadership and Readiness of the *K-12 One-to-One Computing Handbook*[43] where the authors state that

"*Successful education reform of any kind, ...is driven by a broadly held and forward-thinking vision for learners. A strong vision articulates clear and compelling learner characteristics or outcomes, and usually articulates the optimal characteristics of the organizations seeking to*

[40] Underwritten by Intel Corporation; "*Toward a One-to-One World: Mobile Computing is the Lifestyle of Learning*"; A Strategy Paper from the Centre for Digital Education; Copyright 2005 e Republic, Inc.; Retrieved August 2006, <http://www.centerdigitaled.com>; p. 2

[41] Moulton, Jim; "*One-to-One Leadership – Brick or Life Preserver?*", Edutopia; The George Lucas Educational Foundation; Retrieved August, <http://www.edutopia.org/community/spiralnotebook/?p=85>

[42] Maine Learning Technology Initiative, "*Suggestions for a Principal Who is New to the MLTI*" (Based on: Successful Strategies for MLTI); Retrieved August 2006, <http://www.mainelearns.org/ovc/story_files/New_Principal_MLTI.doc>

[43] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community*"; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>, Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>

produce that change." The vision for one-to-one computing must be a clear, concise picture of the future and should be collectively developed and widely communicated.

The Centre for Digital Education[44] also emphasizes the need for an executive sponsor or champion in a laptop or tablet PC program. This champion, whether they are the superintendent, principal or education technology specialist should be aligned with a decision maker who has the authority to launch a project.

The International Society for Technology in Education (ISTE) National Educational Technology Standards (NETS) for Administrators web site offers principal, district program director and superintendent profiles that may help leaders reflect on their readiness to guide one-to-one mobile computing and/or other technology integration projects. Each profile is based on the *Technology Standards for School Administrators Framework, Standards, and Performance Indicators*[45]. Six task areas are delineated including: leadership and vision; learning and teaching; productivity and professional practice; support, management, and operations; assessment and evaluation; and social, legal and ethical issues. See http://osx.latech.edu/administrators/a_profiles.html for links to these profiles.

The document entitled *1:1 Computing: A guidebook to help you make the right decisions*[46] suggests that effective leaders command respect, take ownership and responsibility, have expertise and experience, and provide guidance and direction as well as inspire others to change. It also suggests that leaders of 1:1 computing initiatives must have a clear, strong well-articulated belief system that is founded on a knowledge base of 1:1 computing and its relationship to curriculum and instruction. See pages 16 to 18 of the *Guidebook* for more information on how effective leaders can build a vision, change the culture, commit to staff development and technical support, establish clear lines of communication and input, and manage, monitor and sustain change.

In summary, when effective leaders create commitment to a shared vision, combine that with a clear understanding of roles, provide financial, instructional and technical support for those involved, and ensure ongoing monitoring and effective communication and collaboration within a school and division, the intended goals for one-to-one computing can be achieved.

"My job as a leader is to try to look out into the future, see what's necessary and then equip my people with whatever it is."[47]

– Angus King, Governor of Maine

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[44] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>, Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>

[45] International Society for Technology in Education; *Technology Standards for School Administrators Framework, Standards, and Performance Indicators*; National Educational Technology Standards for Administrators, Copyright © 2002; Retrieved August 2006, <http://osx.latech.edu/administrators/pdf/NETSA_Standards.pdf>

[46] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*; a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>, p. 16

[47] Lemke, Cheryl, Martin, Crystal; *One-to-One Computing in Maine: A State Profile*, December 15, 2003, Retrieved August 2006, <http://www.metiri.com/NSF-Study/ME-Profile.pdf>

6.2. *Planning*

"Careful planning is essential. A solid plan will help districts initiate and sustain [one-to-one programs]."[48]

Leadership and commitment are strengthened by thorough and inclusive planning. The Centre for Digital Education[49] states that "*it is most important that teachers and administrators share vision and work collaboratively. Technology directors and their staff are also critical to accomplishing successful one-to-one computing initiatives.*"

In another document[50], the Centre for Digital Education promotes the creation of a task force, an implementation team and an evaluation team. The task force should be comprised of representatives from technology, instruction, and administration and should be created prior to implementing any one-to-one computing initiative. This task force should organize and study the planning process, investigate the feasibility of the initiative, explore various funding options including partnering with the laptop vendor, and communicate regularly with all stakeholder groups.

The authors go on to state that successful one-to-one initiatives typically have three things in common:

1. a thorough evaluation of the costs;
2. a clear understanding of the total cost of ownership; and
3. a comprehensive documented plan (which often includes a small-scale pilot project to work out details) which is communicated to the stakeholders.

Plans should address overall learning goals, implementation, infrastructure, curriculum, vendor partners, facilities, funding, legislation, and maintenance.

The plan should address all program parameters, overall learning goals, implementation, infrastructure, curriculum, vendor partners, facilities, funding, legislation, and maintenance.

The authors provide a sixteen point strategic planning checklist to help administrators get ready to initiate one-to-one computing programs. This checklist includes items from establishing a task force, automating the gradual deployment of equipment, and ensuring power options are available to providing teachers with their laptops and adequate training months in advance, establishing benchmarks, and having a plan for cycling aging computers out of the program.

In a third document[51], some of the basic components of a recommended planning process are put forward including issues and questions that should be considered (see the table below). The steps in the planning process put forward in this *Guidebook* are: conduct an environmental scan, conduct a SWOT (strengths, weaknesses, opportunities, threats) analysis, form planning teams, define the mission and vision, establish goals and objectives, define strategies and specific action plans, format the plans in a project plan and establish the monitoring and evaluation process.

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[48] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>

[49] Ibid.

[50] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>

[51] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>, p. 14

Table 1: Planning Issues

Issue	Questions
Vision	Where are we now and where do we want to be in the future? How do we get there? How will we know that we are successful?
Leadership	Who are the teacher, administrator, technology and community leaders of this initiative? What are the obstacles/challenges? What are the opportunities
Funding	What is the total solution? What is the true total cost of ownership? How will we pay the total cost now and in the future?
Implementation	Where will we start? What is the best strategy? Should we start with teachers first? Should we pilot the program in one grade level or even in one classroom? How will we expand the program to all students?
Professional learning	What initial professional development is needed? How will we time it? What ongoing opportunities for professional growth will teachers, IT staff, counselors, and administrative support need? How will we share best practices?
Situational awareness	How will implementation of a 1:1 initiative impact the culture, climate, budget, community, relationships of the school and district? What are the pros and cons?
Communication	Who are our key stakeholders? Are we clearly informing them about the plan? Do we have buy-in from everyone including parents/caregivers, local community leaders and associations?
Evaluation	What metrics do we have defined to evaluate the success of the program? What systems do we have in place to identify future adjustments that may need to be made to the program?

In *Blueprint Solutions for K-12 One-to-One Computing Initiatives,*[52] six implementation components are identified: leadership, funding, infrastructure, professional development, curriculum and results. Planning advice is given in each of these areas and includes such steps as: building a task force, identifying stakeholders, determining objectives, aligning existing policies, creating a strategic plan, maximizing communication, changing the culture, creating funding options, acquiring computers, providing insurance protection, building the network, providing ongoing professional development, ensuring teachers and students have access to digital resources, and evaluating results.

Grigano[53], technology director for East Rock Magnet School (a federal government test site for laptop learning), offers the following 12 tips for implementing a wireless laptop program:

1. **Build a Wireless Foundation:** Grigano suggests either mounting access points on portable laptop carts or, better still, strategically place access points throughout the school building to make it ensure maximum flexibility (in classrooms, cafeterias, libraries, offices).
2. **Choose a Laptop:** Cheapest isn't always the best Grigano advises. He suggests carefully consider these essential technical requirements: brand name computer with a 3-year warranty; 512MB; built-in wireless cards; durable construction (magnesium alloy case); long battery life; clear and visible screen from all angles; and lightweight for ease of use.
3. **Choose the Correct Cart:** If carts are to be used, Grigano recommends sturdy durable carts which offer the strongest possible locks, built-in charging capabilities with surge suppressor, fully welded construction, long power cords, and reconfigurable module shelves.
4. **Build the Network Infrastructure:** Grigano suggests that laptops will work at peak performance if these conditions are met: proper CAT 5 wiring; fiber optic backbone; quality network switches and access points; high-speed broadband connection; and reliable and efficient servers.
5. **Ensure Foolproof Configuration:** The following steps are recommended by Grigano to avoid configuration glitches: 1. create a copy of all the curriculum products and other software you'll be using during the year; 2. make a clone of this image by copying to CDs; 3. install the image on all laptops prior to deployment or when a laptop fails; and 4. install desktop security software on all laptops to prevent hacking.
6. **Take Additional Security Measures:** Ensuring all users have unique individual usernames and passwords, configuring personal drives (P drives) for each user so they can save work to the school's server, and labeling all laptops and cart shelves are important security and accountability measures, Grigano states.
7. **Consider Storing and Charging Needs:** If carts are being used storing laptops in a safe and secure cart will help to prevent theft. Students will need to be trained to return their laptop to the same marked shelf every day and be responsible for plugging them in the charger. Theft prevention strategies should also be discussed with students who are taking their laptops home.
8. **Provide Professional Development:** Grigano believes it is important to provide staff with their laptops first and train them months in advance of student deployment. Initial and ongoing professional development are critical. Useful approaches include meeting as small groups for two-hour sessions within or after the school day.
9. **Hold a Parent Orientation:** Grigano sends out a letter informing all parents that their child will be using a laptop and a mandatory meeting will take place. At the meeting, parents should be given a taste the types of lessons, homework assignments, and Web sites they can expect their children will experience when using their laptops. He also provides parents with

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[52] Underwritten by Intel Corporation; *Blueprint Solutions for K-12 One-to-One Computing Intiatives - A resource for education leaders and others interested in implementing one-to-one anytime, anywhere computing in K-12 education*; Copyright 2005; Retrieved August 2006, <http://www.convergemag.com/blueprint/cd/02.PDF>

[53] Grignano, Domenic; "*12 Tips for Launching a Wireless Laptop Program*"; techLEARNING; Oct 15, 2004; Retrieved August 2006, <http://www.techlearning.com/shared/printableArticle.jhtml?articleID=49901145>

an Acceptable Use Policy and has them sign a permission form allowing their child to participate in the program.

10. **Stagger Student Deployment:** He suggests a staggered deployment of laptops (e.g., one grade level every two weeks). Training should include a big-picture discussion about how the technology works, rules and regulations such as how to carry the laptop and acceptable uses, and instruction on basic keyboarding and networking skills.
11. **Ensure Timely Technical Support:** Grigano states that teachers will be convinced laptops are useful and effective in the classroom if there's ongoing professional development; the technology facilitator is available on an as-needed basis during the day; and broken or malfunctioning laptops are fixed within a few days. He recommends having five loaners available for every 100 laptops deployed.
12. **Model Effective Technology Integration:** As a technology director/coordinator, Grigano models 21st century lessons to teachers, showing them how to transform traditional teaching methods so that technology is not an add-on. He suggests visiting http://eastrock.org/units.htm for sample interdisciplinary lessons.

Warschauer[54] suggests the following considerations are vital to planning a laptop program: put education goals first; keep in mind the total cost of ownership; choose a good vendor; practice creative financing; leverage student technology talents; keep students on task; foster teacher collaboration; consider block scheduling; go slowly; and plan for evaluation.

The guidelines for successful technology initiatives in K-12 schools listed in the *K-12: One-to-One Computing Guidebook*[55] are:

> 1. *focus on learning WITH technology, not ABOUT technology;*
> 2. *emphasize content and pedagogy, and not just hardware;*
> 3. *give special attention to professional development;*
> 4. *engage in realistic budgeting;*
> 5. *ensure equitable, universal access; and*
> 6. *initiate a major program of experimental research.*

The National Education Plan recommends the following action steps: strengthening leadership, considering innovative budgeting, improving teacher training, supporting e-learning and virtual schools, encouraging broadband access, moving toward digital content, and integrating data systems.

Section 3 of the *Guidebook* goes on to suggest that a first step should be developing and communicating a shared vision which will likely be comprised of policy, coordination, implementation components, and supported by a detailed communications plan.

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[54] Warschauer, Mark; *Going One-to-One*; Educational Leadership, Learning in the Digital Age; December 2005, Volume 63, Number 4, Pages 34-38

[55] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community* "; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; p. 5

Other resources to support planning one-to-one mobile computing can be found on the One-to-One Institute web site (see http://spartv.crt.net/121/index.cfm). The One-to-One Institute is an American non-profit organization that helps states and school districts improve student achievement and engagement through one-to-one learning programs. Their goals are:

- to expand one-to-one teaching and learning programs to states and school districts,
- to serve as a national clearinghouse for information and advice on one-to-one teaching and learning, and
- to promote one-to-one teaching and learning program models to educators and government leaders.

The previous discussion emphasizes the need for a thorough and consultative planning process when undertaking a one-to-one mobile computing initiative.

6.3. *Educational Goals*

"It is not the laptop or the technology that determines the success of the project; it is what you do with the equipment. If you are going to embark on this type of project, do it because it enhances learning, not because it is fashionable. Develop a program that will engage teachers and students in the learning process."

- response from Center for Digital Education Research

Another key to successful one-to-one mobile computing initiatives is to focus on learning and teaching, that is, establish clear educational goals.

One-to-one mobile computing has the potential to address the learning needs and preferences of the 21st century learner as summarized in the *DRAFT Online Learning (e-Learning) Environmental Scan: Needs and Preferences / Issues / Trends and Promising Practices*. This Scan states that, "Students need and want to be engaged in their learning. Engagement for today's learner is tied to choice, clear expectations, relevant and meaningful curriculum, opportunities for team work, communication, cooperation and collaboration with peers and their teachers, being part of the decision-making process, multi-sensory interactive environments, personalization options, and use of a variety of appropriate technologies.[56]

Barrios' report[57] supports this statement by identifying the following six critical elements for 21st century learning: 1. emphasize core subjects; 2. emphasize learning skills including information and communication skills, thinking and problem-solving skills, interpersonal and self-directional skills; 3. use tools including computers, information and communication technologies, audio, video and other multimedia tools; 4. create authentic learning environments that make content relevant to students (take students out into the world and bring the world into the classroom), create opportunities for interaction with others (teachers, students, experts) within and beyond the school; 5. raise global awareness and increase financial, economic, civic and business literacy; 6. balance and strengthen standardized and classroom assessments to ensure that they measure the full range of core subject outcomes as well as outcomes associated with 21st century skills in a timely way. (Note that Barrios's discussion is based on information from the Partnership for 21st Century Skills <http://www.21stcenturyskills.org/>.)

Educational goals that emphasize 21st century learning require the seamless integration of curriculum and technology. The seamless use of technology to achieve learning outcomes can take many forms: testing scientific theories using simulations; collecting data using probes or from reliable secondary sources on the Internet and then organizing that data using spreadsheets or databases; using multimedia to present interpretations of and conclusions based on the collected data). When done well, these activities foster independent thinking, problem solving, and collaborative learning[58].

Educational goals that emphasize 21st century learning require the seamless integration of curriculum and technology.

The *K-12 One-to-One Computing Handbook (2005)* stresses that curriculum-technology integration is a paramount objective in 1:1 initiatives but this convergence is also one of the foremost challenges schools face. *"Progressing toward learning objectives requires modeling*

[56] Learning Cultures Consulting Inc. for Alberta Education; "*DRAFT Online Learning (e-Learning) Environmental Scan: Needs and Preferences / Issues / Trends and Promising Practices*", March 2006

[57] Barrios, Tina, et al; p. 56

[58] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions. Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>

approaches based on other successful programs and ultimately developing methodology for measuring results from your one-to-one initiative."[59] 21st century curriculum, quality multimedia resources, software, and ongoing, embedded professional development can help to achieve the desired educational goals of a one-to-one mobile computing initiative.

"If we don't provide students with 21st century skills, ...then we're doing them a huge disservice. The world our students live in is not the world we grew up in. The world they're going to work in involves access to technology and it requires these skills to function."[60]

[59] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>, p. 6

[60] Ibid, p. 4

6.4. *Curriculum & Multimedia Resources, & Software*

"Think content. The state and the nation should be investing in research and development of high-quality, high-tech digital content that takes full advantage of digital learning."

– a Michigan Educator[61]

Curriculum that integrates 21st century skills is essential to achieving the educational goals described in Section 6.3. Access to current, multimedia resources provided through learning object repositories (e.g., LearnAlberta.ca), e-texts infused with interactive elements (e.g., Alberta's Science 9 e-texts), licensed databases of reference materials (e.g., encyclopedias, atlases, dictionaries, journals, etc.), RSS feeds, web logs (blogs), 'ask the expert' sites, virtual tours, and other curriculum-aligned resource sites (e.g., Marco Polo, 2learn.ca, Mathletics, Project Gutenberg, etc.) are essential to creating an information-rich environment in the one-to-one classroom. Add software (e.g., word-processor, spreadsheet, database, calendar, presentation software, etc.) and multiple means of communication (e.g., e-mail, messaging, web-conferencing, video conferencing, face-to-face, phone) to the mix, and students and teachers are then enabled to track, organize and/or present the information, collaborate and build their understanding and skills, and share their learning. Employing curriculum that infuses information and communication technology (ICT) outcomes and using multimedia resources and software to realize both content and ICT outcomes are essential to successful 1:1 computing initiatives.

The studies referred to in Section 5.1 and 5.2 of this review occurred in provinces or states where provincial or state curriculum outcomes/standards, including technology outcomes/standards, are mandated (see Section 10 for links to provincial and state curriculum documents for Alberta, British Columbia, Florida, Indiana, Michigan, and Virginia). Alberta has mandated curricula in core and optional programs. Information and communication technology (ICT) outcomes are infused in many of these programs of studies. The ICT outcomes are articulated in a stand-alone document as well, however, the ICT curriculum is not intended to stand alone, but rather to be infused throughout all curricular areas. The philosophy of infusing or integrating ICT is shared by all those whose 1:1 mobile computing initiatives are profiled in this review.

Three attributes of quality for digital content:

1. encourages student engagement and motivation to learn;

2. flexible and adaptive; and

3. provides teachers and administrators with information to improve student performance.

Digital content or multimedia resources abound. The *Digital Content Framework Discussion Guide*[62] describes three attributes of quality digital content as follows:

1. Encourages student engagement and motivation to learn;
2. Flexible and adaptable; and
3. Provides teachers and administrators with information to improve student performance.

The *Guide* goes on to describe common features of digital content, how digital content can improve student learning, the advantages of digital content, and common types of digital content packages. Myths and facts about digital content are discussed (e.g., "*Myth: there is no evidence that*

[61] Lemke, Cheryl; Martin, Crystal; *One-to-One Computing in Michigan: A State Profile*; April 7, 2004; Retrieved August 2006, <http://www.metiri.com/NSF-Study/MIProfile.pdf>; p. 23

[62] Abbott, Jill, et al; Blueprint Solutions: *Digital Content Framework Discussion Guide*; Released August 2006; Retrieved August 2006, <http://www.convergemag.com/blueprint/story.php?id=100615>

investing in technology or digital content results in learning. Fact: Actually, many technology initiatives are documenting improved learning."[63]). The merits of prepared digital content versus raw Internet content and comprehensive packages versus collections of single items are debated. Issues related to professional development, funding and legislation are also discussed. Action steps for preparing to adopt digital content are also put forward. For those new to the realm of digital content, this *Guide* provides a concise overview.

The following table provides a concise overview of the kinds of software that support one-to-one computing environments.

Table 2: Software for Use in Project-based Classrooms[64]

	Graphic Organizer	Presentation	Web Authoring	Photo Editing & Graphics	Digital Video Editing	Multimedia Authoring	E-mail & Conferencing	Word Processing	Spreadsheets	Databases
Information and Media Literacy Skills: Analyzing, accessing, managing, integrating, evaluating, and creating information in a variety of forms and media. Understanding the role of media in society.	●●●	●●	●●●	●●●	●●●	●●●	●●	●●	●●	●●
Communication Skills: Understanding, managing, and creating effective oral, written, and multimedia communication.	●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	●●
Critical Thinking and Systems Thinking: Exercising sound reasoning in understanding and making complex choices; understanding the interconnections among systems.	●	●●●	●●●	●●	●●●	●●●	●●	●●	●●●	●●●
Problem Identification, Formulation, and Solution: The ability to frame, analyze, and solve problems.	●●●	●●	●●	●	●●	●●	●●	●●●	●●●	●●●
Creativity and Intellectual Curiosity: Developing, implementing, and communicating new ideas to others.	●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	●●
Interpersonal and Collaborative skills: Demonstrating teamwork and leadership; adapting to various roles and responsibilities; and working productively with others.	●	●●	●●	●	●●	●●	●●●	●	●	●
Self-direction: Monitoring one's own understanding and learning needs, locating appropriate resources, and transferring learning from one domain to another.	●●●	●●	●●	●●	●●	●●	●●	●●	●●	●●
Accountability and Adaptability: Exercising personal responsibility and flexibility in personal, workplace and community contexts.	●	●	●●	●	●●	●●	●●	●	●	●
Social Responsibility: Acting responsibly with the interests of the larger community in mind; demonstrating ethical behavior in personal, workplace, and community contexts.	●	●●	●●	●	●●	●●	●●	●	●	●

KEY: ●●● = Software strongly supports this 21st century skill
●● = Software often supports this 21st century skill
● = Software can support this 21st century skill

[63] Ibid, p. 6
[64] Barrios, Tina, et al: p. 93

The previous discussion emphasizes the importance of ICT-infused curricula, quality digital content, and software tools to the 1:1 mobile computing classroom, all of which will help students and teachers acquire knowledge, skills and attitudes for the 21st century.

6.5. *Professional Development*

"PD planning and implementation based on individual assessments must begin early in the process and be ongoing for teachers, administrators and staff."[65]

Research emphasizes the importance of ongoing embedded professional development in any educational reform including one-to-one mobile computing. Resources that support the planning of one-to-one mobile computing initiatives concur.

In *Blueprint Solutions for K-12 One-to-One Computing Initiatives*[66] the authors contend that professional development is an ongoing process that should:

- *Create an environment that fosters risk-taking and allows for mistakes;*
- *Allow instructors to take laptops home;*
- *Provide teachers and administrators with laptops approximately one year prior to an implementation and begin development early;*
- *Provide teachers guidance to enhance and evolve pedagogical repertoires with technology;*
- *Create a learning environment offering informal opportunities for administrators, staff and teachers to share best methods;*
- *Train teachers to address connectivity interruptions during class;*
- *Create master usage guidelines to help teachers identify when the technology becomes a distraction;*
- *Provide hands-on training and online instruction for basic computing skills;*
- *Don't make assumptions about users' skill level, even with the simplest functions, such as keyboarding;*
- *Post a Q&A session online that helps teachers incorporate online instruction into classes; and*
- *Save time by using electronic templates for administrative details and routine reporting.*

In *1:1 Computing: A guidebook to help you make the right decisions* [67], the authors state that 1:1 computing initiatives **need to make ongoing, standards-based, high quality educator professional development one of their goals**. They go on to say that teachers need a variety of methods and opportunities to develop their competencies, to know how to effectively integrate technology into the learning environment, and to collaborate with others, sharing best practices.

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[65] Underwritten by Intel Corporation; "*Toward a One-to-One World: Mobile Computing is the Lifestyle of Learning*", A Strategy Paper from the Centre for Digital Education, Copyright 2005 e Republic, Inc.; Retrieved August 2006, <http://www.centerdigitaled.com>, p. 6

[66] Underwritten by Intel Corporation, *Blueprint Solutions for K-12 One-to-One Computing Intiatives - A resource for education leaders and others interested in implementing one-to-one anytime, anywhere computing in K-12 education*, Copyright 2005, Retrieved August 2006, <http://www.convergemag.com/blueprint/cd/02.PDF>

[67] Underwritten by Hewlett Packard, Intel Corporation, Microsoft, *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions, Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>, p. 7

Mark Edwards, Superintendent of Schools in Henrico Count, Virginia supports what these resources say and states, *"At the heart of our laptop program is a firm commitment to teacher training. Embracing the concept of a learning community means giving teachers the skills and tools they need to be effective."*

Florida took the preceding advice to heart and recommended that **successful professional development must be a guiding principle in all one-to-one mobile computing initiatives**. Barrios[68] suggested that this meant PD must: be held on a continuous basis; provide mentors, coaches or peer teammates to model appropriate integration strategies in actual classrooms; give teachers feedback on their performance; and hold teachers accountable for implementing instructional strategies and student learning. Various mentorship models are possible. (Note: One of the recommended resources in the *K-12 1:1 Computing Handbook (2005)* is a literature review of various models of technology mentoring (see http://www.public.iastate.edu/%7Emstar/mentor/Technology_mentoring0128.htm). Some of the models discussed involve using graduate or undergraduate education students as mentors, and adopting the Generation www.Y mentoring model where grades 6 to 8 students partner with teachers. The authors emphasize the creation of learning communities among and between mentors and mentees.)

What must teachers know and be able to do in a 1:1 computing classroom? Teachers need basic computer operation skills but more importantly they need to be able to integrate technology and curriculum. (See a complete listing of the U.S. National Educational Technology Standards for Teachers at http://cnets.iste.org/teachers/pdf/Appendix_A.pdf. See http://www.education.gov.ab.ca/educationguide/pol-plan/polregs/421.asp for Alberta's *Teaching Quality Standard*.). Being effective in a one-to-one computing classroom also means that teachers need to create an environment that is different from traditional teaching and learning environments. The following table describes how classroom environments need to change to ensure success.

Table 3: A Comparison of Traditional and New Learning Environments[69]

Traditional Learning Environments	*New Learning Environments*
Teacher-centered instruction	Student-centered learning
Single-sense stimulation	Multi-sensory stimulation
Single-path progression	Multi-path progression
Single media	Multimedia
Isolated work	Collaborative work
Information delivery	Information exchange
Passive learning	Active/exploratory/inquiry-based learning
Factual, knowledge-based	Critical thinking and informed decision-making
Reactive response	Proactive/planned action
Isolated, artificial context	Authentic, real world context

The preceding discussion emphasizes the importance of professional development and describes what is needed but how have 1:1 mobile computing initiatives scored in terms of providing adequate professional development?

Brumfield's summary[70] of the results of a "teachers talk tech" survey revealed that although nearly 20 percent of the teacher respondents are still getting no professional development related to technology integration, **researchers contend there is a clear link between professional development in technology use, classroom integration of technology, and improved student**

[68] Barrios, Tina, et al, p. 8

[69] International Society for Technology in Education (ISTE) NETS Project, National Educational Technology Standards for Students, June 1998, p. 2

[70] Brumfield, Robert, *"Teacher development key to tech success. Survey confirms importance of professional development to tech integration"*, eSchool News, July 21st, 2006, Retrieved August 2006, <http://www.eschoolnews.com/news/showstoryts.cfm?Articleid=6450>

performance. According to the survey, 78 percent of teachers who have had at least 16 hours of professional development in technology say they incorporate 21st-century skills into their curriculum and believe students' academic performance is enhanced with the use of classroom computers. The biggest 'aha' from the survey was that **a direct correlation can be made, based on statistics, between hours of professional development and how thoroughly technology is being integrated into the classroom.**

In Maine, successful PD focused on shared resources and best practices, group problem solving of classroom challenges, and technology skills taught within the context of how they can be used to teach academic content.

In Maine, where educational objectives and teaching and learning were clearly the focus in their seventh grade laptop initiative, teachers were involved in project leadership as well as ongoing professional development. Muir[71] indicated that in Maine's experience, successful PD focused on shared resources and best practices, group problem solving of classroom challenges, and technology skills taught within the context of how they can be used to teach academic content. Teachers also received their laptops months in advance and attended a two-day summer institute.

Even with the degree of intentionally planned professional development in Maine, teachers felt that more time and professional development was needed to fully integrate technology into teaching and learning[72]. They preferred professional development that was offered during early release times.

The Mitchell Institute's final report[73] on the PCHS laptop initiative provides the following results related to its professional development efforts. The laptop program began with a 2 ½ day Apple training session but several teachers and administrators mentioned that this was insufficient. PCHS also conducted a technology training "boot camp" which focused on software training in digital film, graphics, and presentation programs, and also included sessions on research, math, and science tools. Technology staff members offered optional training sessions after school throughout the year.

Still, nearly one-half (46%) of the teachers surveyed disagreed with the statement "I have had adequate professional development opportunities." However, 68% said that they have participated in professional development activities that have helped them integrate technology into the curriculum. Teachers also reported that, since the laptop program began, they have spent between 3 and 100 hours on professional development, with a median answer of 15 hours.

When asked what formats they prefer for professional development, all respondents indicated that they preferred training during early-release time throughout the school year. 64% preferred teaming with another teacher or student to learn more about technology, 50% preferred a series of after-school training sessions during the school year, 41% preferred a two-day training session at the end of summer; and 27% indicated that they preferred two-day training at the beginning of summer and just-in-time training during class time.

When asked what training was still needed, teachers asked for: more training in specific software programs (62%); content-specific training in their discipline (31%); training in teaching methods, such as differentiated learning (15%); and training in the use of peripherals (e.g., projectors and

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[71] Muir, Mike; Knezek, Gerald; Christensen, Rhonda; "*The Power of One-to-One: Early Findings from the Maine Learning Technology Initiative*"; Learning and Leading with Technology; Volume 32, Number 3, Copyright 2004 International Society for Technology in Education (ISTE); p. 7

[72] Mitchell Institute; *Great Maine Schools Project: One-to-One Laptops in a High School Environment, Piscataquis Community High School Study, FINAL REPORT*; February 2004; Retrieved August 2006, <http://www.mitchellinstitute.org/Gates/pdf/One-to-One_Laptops_Report.pdf>, p. 6

[73] Mitchell Institute; *Great Maine Schools Project: One-to-One Laptops in a High School Environment, Piscataquis Community High School Study, FINAL REPORT*; February 2004; Retrieved August 2006, <http://www.mitchellinstitute.org/Gates/pdf/One-to-One_Laptops_Report.pdf>, p. 10-11

digital cameras) (15%). Teachers also expressed a need for intensive training and refresher courses in critical software programs.

What resources exist to support professional development? The *K-12 1:1 Computing Handbook (2005)* lists several online professional development resources (see p. 29 for a complete listing).

In Alberta, the 2learn.ca Education Society, in alliance with Alberta Education, the Alberta Teachers' Association, the University of Alberta, Faculty of Education, the College of Alberta School Superintendents and TELUS, provides several resources and tools to support curriculum technology integration. See http://www.2learn.ca/mapset/mapset.asp for resources that:

- support the implementation of information and communication technology (ICT) outcomes,
- support teachers in their use of tools including word processors, spreadsheets, multimedia, web development, databases, video conferencing and assistive technologies, and
- provide tech tips, search tips, Alberta programs of studies summaries, annotated web links, K-12 subject-specific e-zines, a freely accessible reference collection, and much more.

The site also provides:

- a Project Centre to support tele-collaborative learning projects,
- an e-mail news service call *Vantage* that offers updates, articles and curriculum links (signup at http://www.2learn.ca/mainregistration/default.html), and
- a 'My Desktop' tool that allows teachers to create resources and store them at 2learn.ca.

This section can be summarized succinctly in the words of a Michigan educator, *"Don't skimp on ongoing, continuous, and well-supported professional development."*[74] Survey teacher readiness and build your professional development plans accordingly, ensuring adequate time and financial resources are allocated.

[74] Lemke, Cheryl, Martin, Crystal, *One-to-One Computing in Michigan: A State Profile*, April 7, 2004, Retrieved August 2006, <http://www.metiri.com/NSF-Study/MIProfile.pdf>, p. 23

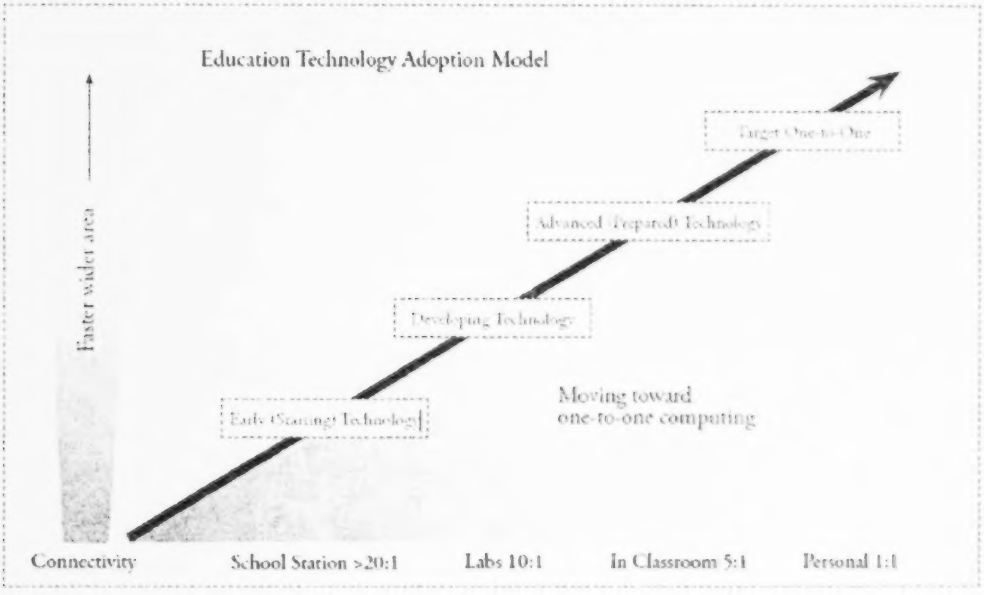
6.6. *Infrastructure and Connectivity*

"Internet connectivity with one hundred percent coverage on the school grounds is a must."[75]

Successful one-to-one laptop initiatives require cost-effective, reliable, regularly-upgraded laptops or Tablet PCs that are powerful enough to enable the required educational uses (see Section 6.4), have a long battery life, and have a reliable, ubiquitous high-speed Internet connection within the school environment. High-speed connections to the Internet in the home environment are also desired. Section 4 of the *K-12 One-to-One Computing Handbook* describe what is needed to equip the one-to-one classroom in terms of hardware, network connectivity and infrastructure and provide a graphic of an "intelligent classroom".

Many schools may still have largely hard-wired computer labs and/or classroom pods (the 2003 student to computer ratio in the U.S. was reported to be 4.4:1)[76]. The Centre for Digital Education has developed a useful graphical representation of the progression of education technology adoption (see the graph below).

Graph 1: Education Technology Adoption Model[77]



Regardless of where a school finds itself in their transition to lower and lower student-to-computer ratios, vendors will be an important part of the implementation team. When selecting a vendor, it is suggested that their reputation and their ability to provide training as well as

[75] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>; p. 7

[76] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community* "; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; p. 7

[77] Underwritten by Intel Corporation, "*Toward a One-to-One World: Mobile Computing is the Lifestyle of Learning*"; A Strategy Paper from the Centre for Digital Education; Copyright 2005 e Republic, Inc.; Retrieved August 2006, <http://www.centerdigitaled.com>; p. 4

deployment and maintenance services are key considerations[78]. See the Centre's suggested list of vendor selection criteria below.

Table 4: Vendor Selection Criteria

VENDOR SELECTION CRITERIA:

- ☑ A true partner with commitment beyond selling hardware.
- ☑ Strong service metrics and domestic-based technical support. The human touch is critical here.
- ☑ Delivers solid equipment with reputation for reliability and value.
- ☑ Can assist with infrastructure development.
- ☑ Will train staff on the use of hardware.
- ☑ Has a delivery plan matching school/district needs, including timing and location of delivery.
- ☑ Will train staff to perform repairs and establish an authorized service center at the school/district.
- ☑ Quickly provides for returns or major repairs that cannot be completed on site.
- ☑ Has an adequate supply of parts.
- ☑ Recognizes need to control costs and can arrange for financing.
- ☑ Will help develop a plan to replace aging computers.

What hardware are schools buying? Muir[79] describes the technology acquired in Maine. Maine's request for proposals was won by Apple. Apple supplied 37,000 12" Apple iBooks (with CD-ROM drives) with a pre-loaded software including office applications (spreadsheet, word processor, database), a web browser, encyclopedia, e-mail, presentation software, desktop video editing, and photo album software. Apple also provided wireless networks, teacher training and technical support. Hinsdale Township High School District 86 in Illinois began its pilot using Toshiba Tablet PCs.[80] The tablet was chosen due to its handwriting, drawing and voice recording capabilities. For example, students' step-by-step math problem solutions can be easily e-mailed to the teacher for assessment. Schools in Connecticut and Ohio are switching to tablets as well for these reasons. See *1-to-1 Computing on the Rise*[81] in Schools for a brief description of some recent mobile computing options.

McLester[82] compiled the following list of companies that offer laptops, Tablet PCs, and networking equipment as well as wireless mobile lab packages, access points and other components. This list may be helpful to support investigations of technology options.

Table 5: Hardware and Mobile Cart Vendors

Hardware	Mobile Carts
Acer America, www.acer.com/us	Bretford, www.bretford.com
Apple, www.apple.com	Datamation Systems, www.pc-security.com
Dell, www.dell.com	Spectrum Industries, www.spectrumfurniture.com
Fujitsu, www.fujitsu.com	Wireless Networking 3Com, www.3com.com
Gateway, www.gateway.com	Alvarion, www.alvarion-usa.com
HP, www.hp.com	Apple, www.apple.com

[78] Underwritten by Gateway, "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*", Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>, Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>, p. 7

[79] Muir, Mike; Knezek, Gerald; Christensen, Rhonda; "*The Power of One-to-One: Early Findings from the Maine Learning Technology Initiative*", Learning and Leading with Technology, Volume 32, Number 3, Copyright 2004 International Society for Technology in Education (ISTE), p. 7

[80] Underwritten by CDW-G <http://www.cdwg.com>, "*One-to-One Computing: A Revolution in Education is at Hand*", Teachers Talk Tech Series White Paper, Received July 2006 from Stakeholder Technology Branch, Alberta Education, p. 2

[81] eSchool News Online staff and wire reports, *1-to-1 computing on the rise in schools*, May 1, 2006, Retrieved August 2006, <http://www.eschoolnews.com/news/PFshowstory.cfm?ArticleID=6278>

[82] McLester, Susan, "*Learn More About Laptops*", techLEARNING, Oct 15, 2004, Retrieved August 2006, <http://www.techlearning.com/shared/printableArticle.jhtml?articleID=49901145>

Hardware	Mobile Carts
IBM, www.ibm.com	Avaya, www.avaya.com
Motion Computing, www.motioncomputing.com	Cisco Systems, www.cisco.com
NEC Solutions America, www.necsam.com	Enterasys Networks, www.enterasys.com
Toshiba, www.toshiba.com	Lucent Technologies, www.lucent.com
ViewSonic, www.viewsonic.com	Proxim, www.proxim.com

As discussed earlier, buying decisions may have to be made in phases. Intel[83] puts forward the following table which depicts an incremental adoption of mobile technology.

Table 6: Incremental Adoption of Mobile Technology

Adoption of Mobile Technology			
PCs	• Desktops in a central location, such as a computer lab or library • Consider purchasing laptops to be used the same way	• Laptops + mobile cart as they can be moved from classroom to classroom • Or one or more laptops designated for each classroom • Teachers may receive their own laptops	• 1:1 laptop distribution to students, teachers, and administrators
Network infrastructure	• Wired LAN	• Wireless LAN	• Wireless LAN
Activities	• Access Internet for research • eLearning with online curriculum • Network access to centralized data and student records for administrators, teachers, and staff	• Students share laptops • Laptops can be used in the classroom, other parts of the building, or outside • Teachers can wirelessly control video projection systems and interactive whiteboards from anywhere in the classroom • Teachers with their own laptops gain flexibility to do their administrative work outside the classroom	• Individualized learning at students' own pace • "Classroom anywhere, learning anytime" • Students can take laptops home to extend learning
Benefits	• Student exposure to PCs and online learning	• More project-based learning • More collaboration • Improved teacher-parent and teacher-peer-administrator communications	• Student-centered, connected learning environment • Personalized computing for individualized learning • Teachers are free to integrate technology fully into instruction as well as assignments
Next steps	• Add laptops • Add mobile cart • Consider long-term cost savings of wireless mobile computing (space, power, wiring, flexibility) • Begin researching access to a wide range of education technology, content, and services to support the curriculum as you increase PC and Internet access	• Add more laptops • Add more carts • Acquire classroom sets of laptops, stored on a recharging cart, so that any classroom can have an experience with ubiquitous computing • Consider starting 1:1 with the lowest grade in the building and equipping each subsequent year's entering class	• Expand interaction beyond the classroom, removing boundaries between schools and communities

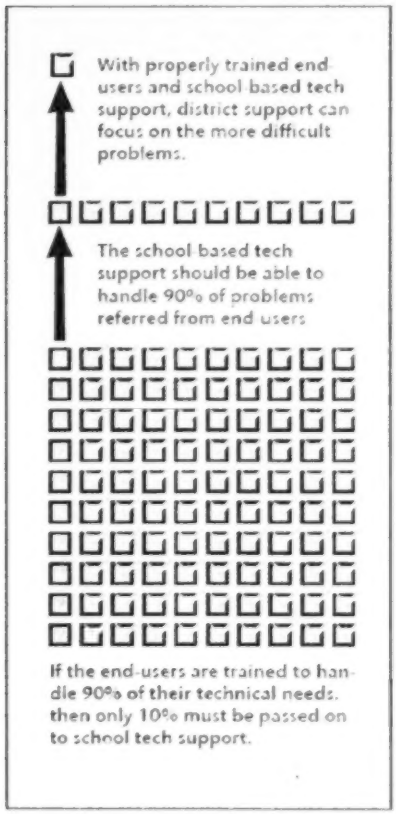
Wherever a school finds itself along the mobile technology adoption continuum, buying decisions should be guided by a clear vision that focuses on learning and teaching and that ensures teachers are adequately prepared and supported.

[83] Intel Corporation, *Wireless laptops transform learning in primary and secondary schools*, Copyright 2005, Retrieved early August 2006, URL no longer active, p 7

6.7. *Technical Support*

"Technical support for a 1:1 program is a key component in starting and sustaining the initiative and should be treated as a core requirement in the overall plan."[84]

Hardware, software, and network malfunctions can be extremely frustrating and can jeopardize the many positive benefits of 1:1 mobile computing. Indiana reported that on-site technical support remains a challenge for them (see Section 5.2). The Mitchell Institute's final report[85] on the PCHS laptop initiative provides some data on the instances of laptops breaking down. Generally speaking, 35% of the students who responded to the survey said their laptop has broken down or been damaged at some point and of these students, most reported that they were without their laptop for a week or more. Technical support therefore, whether provided by outside vendors, at the school, division, and/or state/provincial level or by some blended approach, is crucial.


With properly trained end users and school based tech support, district support can focus on the more difficult problems.
The school based tech support should be able to handle 90% of problems referred from end users
If the end-users are trained to handle 90% of their technical needs, then only 10% must be passed on to school tech support.

Factors to consider when planning for technical support include: 1. service level agreements, 2. escalation paths, 3. acceptable response times and down times, 4. best practices (e.g., Service Management Reference Model), 5. building-level and backend data centre infrastructure management, 6. device management and distribution processes, 7. help desk services and other levels of support, and 8. disaster recovery or business continuity plans (along a continuum of daily operational risks to large-scale disasters).[86]

In addition to the factors for consideration listed above, the *K-12 1:1 Computing Handbook (2005)* suggests that vendors should be consulted regarding their training capacity and warranty programs. Insuring laptops is also a consideration if a division or school is considering owning the hardware. Finally, when budgeting for a 1:1 mobile computing initiative, it is advised that technical support costs, including repair and replacement, not be underestimated.

Barrios contends that technical support which employs a tiered approach can reduce the frustration and help to create a positive 1:1 computing experience for all concerned[87].

Figure 1: 3-Tiered Approach to Technical Support in a One-to-One Computing Environment

She recommends a three-tiered approach (see Figure 1 above).

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[84] Underwritten by Hewlett Packard, Intel Corporation, Microsoft, *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions, Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>, p. 40

[85] Mitchell Institute, *Great Maine Schools Project: One-to-One Laptops in a High School Environment, Piscataquis Community High School Study, FINAL REPORT*, February 2004, Retrieved August 2006, <http://www.mitchellinstitute.org/Gates/pdf/One-to-One_Laptops_Report.pdf>, p. 10-11

[86] Ibid, p. 40

[87] Barrios, Tina, et al, p. 17

- Tier 1: End User – Students and teachers receive training in trouble-shooting and problem-solving frequently encountered glitches, basic operations, and proper care of the laptops/tablets. School-based student helper programs have also been successful aspects of this level of technical support.
- Tier 2: School Level – School-based teacher, IT specialist or technician deals with software, most network issues, and routine hardware tasks (replacement or upgrading).
- Tier 3: District Level – Technology director or designate handles not-routine hardware problems and difficult network issues.

In wide laptop rollouts, this tiered approach is sometimes complemented by an online system that provides support tips, FAQs, and instructions, states Barrios.

Technical support is another crucial component to the success of 1:1 mobile computing.

6.8. Community Support

"A community relations program that educates the public is imperative to any laptop initiative."[88]

Community support is identified by ISTE[89] as an essential condition to the successful implementation of technology initiatives. To garner community support, the North Central Regional Technology in Education Consortium[90] recommends that strategies be developed that will address the following questions:

- What kinds and levels of community support are needed to ensure that your one-to-one mobile computing initiative is successful and sustainable?
- What public relations activities will you engage in to promote the effective long-term implementation of your one-to-one mobile computing initiative?
- How will you create opportunities for school staff and the community to share information in order to foster positive relationships?
- How will you garner support from community and business leadership, for example, in long-term public and private partnerships?
- How will you connect and interact with related organizations (museums, libraries, adult literacy programs, higher education, community-based organizations, and so on) to improve student learning?
- How will you leverage investments (e.g., provide training and support for parents and community members) to provide technology access and service to the wider community?
- What other human and community resources exist, including businesses and libraries, to support the initiative?
- How and when will you report results to stakeholders?

Parents should be informed at all stages of planning and implementation.

Section 3 of the K-*12: One-to-One Computing Guidebook*[91] suggests that parents should be informed at all stages of planning and implementation. The authors recommend hosting a mandatory orientation meeting for parents and students where they will have an opportunity to ask questions, see demonstrations, discuss acceptable use policies, and understand the rules and regulations as well as the use and care of the technology. It is also recommended that key questions should be answered at the parent orientation, including:

- What is the instructional/learning value of the initiative?
- How will the initiative be sustained in the long term?
- What degree of access will be provided at school and at home?

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[88] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community* "; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; p. 24

[89] International Society for Technology in Education (ISTE); National Educational Technology Standards (NETS); *Essential Conditions for Implementing NETS for Administrators*; Copyright ISTE 200-2005, Retrieved August 2006, <http://cnets.iste.org/administrators/a_esscond.html>

[90] Adapted from Garnering Public Support at http://www.ncrtec.org/capacity/guidewww/garner.htm.

[91] Underwritten by Gateway; "*K-12 One-to-One Computing Handbook: A compete resource for policy makers, school boards, superintendents, and the K-12 community* "; Copyright 2005, Centre for Digital Education<http://www.centerdigitalgov.com/>; Retrieved August 2006 (requires free registration), <http://www.gateway.com/work/pdf/edu/K12_1to1_Computing_Handbook.pdf>; p. 23

- How will security be handled?

The *1:1 Computing: A guidebook to help you make the right decisions*[92] offers additional advice about garnering community support and understanding. This guidebook suggests that community support is gained by having all stakeholders involved in the process of determining what to do and how to do it. Using consensus-building strategies to agree on goals, define the decisions to be made, brainstorm solutions, identify pros and cons of alternatives, analyze the forces for and against implementation, make the decisions, and put into place the best strategies to achieve the goals are deemed as important steps along the way. It is suggested that an important fist step is to evaluate your district's relationship with its education community (e.g., are standing advisory committees in place?, is there a regular system of communication with stakeholders?, is input regularly sought with respect to district decisions and governance?).

Strong community involvement characterized many of the wireless computing initiatives in the U.S. (see Section 5.2). Much can be learned from these experiences to ensure successful implementation of 1:1 mobile computing.

[92] Underwritten by Hewlett Packard, Intel Corporation, Microsoft; *1:1 Computing: A guidebook to help you make the right decisions*; a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>; p. 14

6.9. Costs

Laptop initiative costs are complex and unique to each local context. Careful consideration of the initiative's educational goals and the resulting requirements for hardware, software, connectivity, wireless networking, security, insurance, technical support, digital content, professional development, communications, and community involvement, as described in the previous sections, is therefore required.

Cost projections for 1:1 mobile computing have been put forward by various sources (e.g., Centre for Digital Education[93], Barrios[94], Rubadeau[95], South Dakota[96] the Commonwealth of Virginia[97]). Each of these time-sensitive cost projections is based on the local situation (i.e., federal, state, provincial, division, and/or school funding models, legislation, existing financial and other resources accessible at the time of the initiative, vendor partnerships, community involvement, etc.). Not all cost projections addressed the same components (i.e., some focused specifically on the costs for hardware and software). Comparability and applicability of these cost projections to the Alberta context are therefore limited.

Although budgets for one-to-one mobile computing will share some common components, actual costs and plans for sustainability will be unique in each education community.

Information was found that related to securing revenue sources for one-to-one mobile computing, but it was based in the U.S. (e.g., *A School Administrator's Guide To Planning for the Total Cost of New Technology*[98]) and therefore has little relevance to the provincial/territorial educational funding context in Alberta.

Sustainability continues to be raised as an ongoing challenge (see Sections 5.2 and 6.11) within existing one-to-one mobile computing pilot projects/initiatives.

Although budgets for one-to-one mobile computing will share some common components, actual costs and plans for sustainability will be unique in each education community. Current and comprehensive estimates of costs that consider the essential components for success, and tested models or plans for sustainability of one-to-one mobile computing remain to be determined.

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[93] Underwritten by Gateway; "*One-to-One Laptop Initiatives: Providing Tools for 21st Century Learners*"; Copyright 2004, Center for Digital Education <http://www.centerdigitalgov.com/>, Retrieved August 2006 (requires free registration), <http://i.i.com.com/cnwk.1d/html/itp/K12WhitePaperHiResFinal05.pdf>

[94] Barrios, Tina, et al; (2004) p. 14

[95] Rubadeau, Ron; (2005) p. 18

[96] Woster, Terry; "*20 Schools to Receive Laptops: Rounds' pilot program criticized by candidates*"; Project Inkwell <http://www.projectinkwell.com>; May 17, 2006, 1:55 am; Retrieved August 2006, <http://www.projectinkwell.com/docs/20schools.pdf>

[97] Lemke, Cheryl, Martin, Crystal; *One-to-One Computing in Virginia: A State Profile*; May 12, 2004; Retrieved August 2006, <http://www.metiri.com/NSF-Study/VAProfile.pdf>; p. 3

[98] Consoritum for School Networking; *A School Administrator's Guide To Planning for the Total Cost of New Technology*; Copyright July 2001; Retrieved August 2006, < http://www.classroomtco.org/tco2class.pdf>

6.10. Benefits

"After more than 10 years studying laptop computing in schools, Saul Rockman (2003) concludes that one of the most important benefits of a laptop program is an increase in 21st century skills."[99]

Educators and researchers alike describe many benefits of one-to-one mobile computing.

Gulek and Demirtas[100] summarized the many benefits that a substantial body of research suggests are possible in one-to-one mobile computing environments where technology is used as an instructional tool to enhance student learning and educational outcomes.

Compared to their non-laptop counterparts, students with individual laptops direct their own learning, report a greater reliance on active learning strategies, readily engage in problem solving and critical thinking, and consistently show deeper and more flexible uses of technology.

"Past research suggests that compared to their non-laptop counterparts, ***students … with their own laptops spend more time involved in collaborative work, participate in more project-based instruction, produce writing of higher quality and greater length, gain increased access to information, improve research analysis skills,*** *and* ***spend more time doing homework on computers****. Research has also shown that these* ***students direct their own learning, report a greater reliance on active learning strategies, readily engage in problem solving and critical thinking,*** *and* ***consistently show deeper and more flexible uses of technology than students without individual laptops****."*

Their own study confirmed these findings. A total of 259 middle school students were followed via cohorts. The data collection measures included students' overall cumulative grade point averages (GPAs), end-of-course grades, writing test scores, and state-mandated norm- and criterion-referenced standardized test scores. The baseline data for all measures showed that there was no statistically significant difference in English language arts, mathematics, writing, and overall grade point average achievement between laptop and non-laptop students prior to enrollment in the program. However, laptop students showed significantly higher achievement in nearly all measures after one year in the program. Cross-sectional analyses in Year 2 and Year 3 concurred with the results from the Year 1. Longitudinal analysis also proved to be an independent verification of the substantial impact of laptop use on student learning outcomes.

Lei[101] reported four benefits of one-to-one computing including: 1. **significant increases in student technology proficiency**; 2. **increased academic achievement** over the school year (using GPA as an indicator); 3. **enriched student learning experiences, expanded horizons, and increased opportunities and possibilities** (as reported in interviews with students); and 4. provided great opportunities for teaching and learning (as reported in interviews with teachers and students).

Barrios[102] devotes one chapter of *Laptops for Learning* to describing the following benefits:

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[99] Barrios, Tina, et al; p. 22

[100] Cengiz Gulek, James; Demirtas, Hakan; *"Learning With Technology: The Impact of Laptop Use on Student Achievement"*; The Journal of Technology, Learning and Assessment; Volume 3, Number 2, January 2005; Retrieved August 2006, <http://www.bc.edu/research/intasc/jtla/journal/pdf/v3n2_jtla.pdf>

[101] Lei, Jing (Syracuse University); Zhao, Yong (Michigan State University); *One-To-One Computing: What Does It Bring To Schools?*; No publication date given, Retrieved August 2006, <http://media.centerdigitaled.com/One-to-One_Computing-Executive_Summary.doc>

[102] Barrios, Tina, et al; p. 22 to

1. **attainment of 21st century skills** (i.e., ability to learn independently, collaborate with peers to accomplish work, and communicate conclusions of your work as well as information and communications skills, thinking and problem-solving skills, and interpersonal and self-directional skills)
2. **improved academic achievement**
3. **transformation of teacher practice** (i.e., less lecture and more individual and group project work, more student-led inquiry and collaborative work, toward constructivist teaching, increases in teachers' use of technology for research, material development, student information management, and communication with colleagues, students and parents)
4. **improved student attitudes and work habits** (Decreases in student absenteeism and declines in discipline problems have also been reported.)
5. **increased parental and community involvement** (higher attendance at school events and meeting, increased communication via digital and face-to-face means, more volunteering, more participation in tutoring programs and computer classes, increased satisfaction ratings)

The pilot projects described by Rubadeau, Davies, Lemke and Martin, Jeroski, Beaulieu and others in Section 5 of this literature review highlight several benefits including:

1. **improved writing skills** specifically as well as **improved academic achievement** across several subject areas (it has been shown that this is especially true for at-risk, Aboriginal, special needs, and low-achieving learners)
2. **improved student-teacher interaction and relations**
3. **increased parental and community involvement**
4. **increased teacher enthusiasm and retention**
5. **positive changes in the teaching and learning environment** (in the way students go about, think about, assess, and demonstrate their own learning)
6. **increases in the quantity and improvements in the quality of student work**
7. **improvements in information and communication skills among students and teachers**

Other reported benefits[103] include: **greater access to resources, information, and up-to-date instructional content**; **increases in student motivation, engagement, interest, organization, and self-directed learning**; **increased professional productivity and greater collaboration among educators**; **improved home-school communication**; **improvements in student attendance, academic rigor, and individualized instruction**; **cost savings**; and **reduced student attrition**.

The Centre for Digital Education[104] states that as a result of deliberate decision-making and disciplined planning, benefits will include: **increased teacher and student use of technology, amplified student motivation and engagement, improved student-teacher interaction, increased access to interactive multimedia content, enhanced student achievement,** and **better student preparation for higher education or career**.

The Maine Education Policy Research Institute (MEPRI), a University of Maine project tasked with reporting on any state-funded educational venture, reported that after only five months of implementation of Maine's 7th grade laptop initiative, **students' engagement and attendance were up, behaviour referrals were down, and technology use within classrooms was up dramatically**. They went on to report that **teachers felt their lessons were more extensive, they**

[103] Underwritten by Hewlett Packard, Intel Corporation, Microsoft, *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions, Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf>, p. 4

[104] Underwritten by Intel Corporation, "*Toward a One-to-One World: Mobile Computing is the Lifestyle of Learning*", A Strategy Paper from the Centre for Digital Education, Copyright 2005 e Republic, Inc., Retrieved August 2006, <http://www.centerdigitaled.com>, p. 2

used more up-to-date information in more depth, and student interest in school and learning increased (Muir, 2004). The Maine Learning with Laptop Study also discovered that the benefits improved if students were allowed to take their laptops home. The final report[105] of the laptop initiative in Maine's Piscataquis Community High School reports similar benefits (i.e., **improved computer skills, increased access to educational resources, boosted student motivation and interest in school, enhanced interaction among students and teachers, greatest improvements in achievement for at-risk and low-achieving students**).

Although more research is recommended (Barrios, Davies), sufficient evidence exists of the many benefits of one-to-one mobile computing.

[105] Mitchell Institute, *Great Maine Schools Project: One-to-One Laptops in a High School Environment, Piscataquis Community High School Study, FINAL REPORT*, February 2004; Retrieved August 2006, <http://www.mitchellinstitute.org/Gates/pdf/One-to-One_Laptops_Report.pdf>, pp. 31

6.11. Issues/Concerns

As with any educational reform or innovation, various stakeholders have raised concerns about one-to-one mobile computing[106]. Chief among these concerns is the **cost of ubiquitous computing**, especially in terms of calculating the **total cost of ownership**, ensuring long term **sustainability**, and addressing concerns about **competing educational priorities**. **Inadequate professional development, technical support, and Internet connectivity** have also been identified as issues when implementing laptop initiatives. **Technical problems with laptops and networks** can cause frustrating disruptions in the teaching/learning process. Teachers have raised concerns about their **lack of "technical readiness" and/or ability to effectively integrate technology**. Concerns have been raised by parents about **inappropriate uses of laptops and handhelds**.

Depending on the degree of planning and communication prior to initiation of a 1:1 laptop program, concerns may also be raised about a **lack of vision, leadership, planning and/or evaluation**. Lei[107] adds that parents are concerned that **children spend too much time on the laptops** and that teachers have concerns that **students are distracted by the Internet, e-mail, games, and music**.

The three most commonly cited concerns of the laptop program at PCHS in Maine were: **potential for distraction in the classroom, non-educational or inappropriate laptop use by some students,** and **technology failure that interrupts planned class activities**[108].

The appetite for one-to-one mobile computing continues to rise in spite of ongoing challenges.

In spite of this seemingly overwhelming list of issues and concerns, the appetite for 1:1 wireless computing initiatives continues to rise[109] based on the benefits reported in the research (see Section 6.10). These issues and concerns must be taken seriously however. Authors of *1:1 Computing: A guidebook to help you make the right decisions* [110] recommend using Force Field Analysis or some similar strategy for evaluating the forces for and against change. (See Section 7 for a summary of the steps in the Force Field Analysis process.) Careful consideration of any opposition must occur prior to implementation of one-to-one mobile computing otherwise the opposition will become a barrier to success.

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[106] Lemke, Cheryl; Martin, Crystal, *One-to-One Computing in Michigan: A State Profile*, April 7, 2004, Retrieved August 2006, <http://www.metiri.com/NSF-Study/MIProfile.pdf>, p. 5-7

[107] Lei, Jing (Syracuse University), Zhao, Yong (Michigan State University), *One-To-One Computing: What Does It Bring To Schools?*, Retrieved August 2006, <http://media.centerdigitaled.com/One-to-One_Computing--Executive_Summary.doc>

[108] Mitchell Institute; *Great Maine Schools Project: One-to-One Laptops in a High School Environment, Piscataquis Community High School Study, FINAL REPORT*, February 2004, Retrieved August 2006, <http://www.mitchellinstitute.org/Gates/pdf/One-to-One_Laptops_Report.pdf>; p. 4

[109] *America's Digital Schools 2006, An Education Survey of National Significance*, Retrieved August 2006, <http://www.ads2006.org/main/index.php>

[110] Underwritten by Hewlett Packard, Intel Corporation, Microsoft, *1:1 Computing: A guidebook to help you make the right decisions*, a special section of Technology and Learning published as a 44 page brochure, November 2005, Copyright 2005 CMP Media LLC, Integrated Marketing Solutions; Retrieved August 2006, <http://download.microsoft.com/download/8/d/c/8dc3ebfe-6849-4534-a4b7-846a8c327874/HP1to1Guide.pdf

6.12. Summary

The previous sections were intended to describe the conditions, that when created together in a holistic manner driven by educational goals, can lead to the successful implementation of one-to-one computing initiatives. In fact, Sections 6.1 to 6.9 highlight most of the "essential conditions for implementing technology in schools" put forward by ISTE (see the table below).

Table 7: Essential Conditions for Implementing Technology in Schools[111]

Shared Vision – The school board and administrators provide proactive leadership in developing a shared vision for educational technology among school personnel, parents, and the community.
Equitable Access – Students, teachers, staff, and administrators have equitable access to current technologies, software, and telecommunications resources.
Skilled Personnel – District leaders and support personnel are skilled in the use of technology appropriate for their job responsibilities.
Professional Development – District leaders and support personnel have consistent access to technology-related professional development for their job assignments.
Technical Assistance – Personnel have technical assistance for maintaining and using technology.
Content Standards and Curriculum Resources – Instructional personnel and school leaders are knowledgeable about content and technology standards, related curriculum resources, teaching methodologies, and the use of technology to support learning.
Student-Centered Teaching – Teaching in all settings includes the use of technology to facilitate student-centered approaches to learning.
Assessment and Accountability – The school district has a system for the continual assessment of effective technology use for improving student learning.
Community Support – The district maintains partnerships and communications with parents, businesses, and the community to support technology use within the district.
Support Policies – The district has policies, financial plans, and incentive structures to support the use of technology in learning and in operations of the district.
External Conditions – Policies, requirements, and initiatives at the national, regional, and state levels support the district in the effective implementation of technology for achieving national, state, and local curriculum and technology standards.

They also align somewhat with the Centre for Digital Education's version of the key components of successful one-to-one mobile computing, called the Blueprint Components[112]. The components include leadership, funding, infrastructure and architecture, curriculum, professional development, and resources and results (see the table below).

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[111] International Society for Technology in Education (ISTE), National Educational Technology Standards (NETS), *Essential Conditions for Implementing NETS for Administrators*; Copyright ISTE 200-2005; Retrieved August 2006, <http://cnets.iste.org/administrators/a_esscond.html>

[112] Underwritten by Intel Corporation, "*Toward a One-to-One World: Mobile Computing is the Lifestyle of Learning*"; A Strategy Paper from the Centre for Digital Education, Copyright 2005 e Republic, Inc., Retrieved August 2006, <http://www.centerdigitaled.com>; p. 7

Table 8: Blueprint Components

Stages	Early (Starting) Technology	Developing Technology	Advanced (Prepared) Technology	Target One-to-One Computing
Example Ratios Students : computer	School Start-in 20:1	Labs 10:1	In Classroom 5:1	Personal 1:1
Leadership	• Create vision • Look at strategies and options • Build a task force	• Plan and set goals • Ensure ongoing communication with stakeholders	• Develop strategic technology plan and implementation plan	• Plan implemented • Easy access to information and resources • Policy created
Funding	• Dig into funding sources — not focused specifically on technology	• Limited availability • Competing demands	• Funding sources focused on technology	• Seek underwriting • Creative sources
Infrastructure and Architecture	• Basic school administration computerization • Limited network	• IT Learning • Labs connected	• IT-enhanced learning • All classrooms connected with teacher's computer • Few students connected	• Provides anytime, anywhere eLearning • Each student has a computer • Policy in place for security and technical support • Consistent access at home and school
Curriculum Solutions	• Textbook only • Evaluate textbooks	• Textbook/Internet (some Web resources) • Introduce courseware	• Textbook/Internet Courseware • Reallocate textbook budget to courseware licenses	• Courseware/Internet/Textbook • Courseware for curriculum, student apps for clients and administration • Use eTextbooks • Rich digital content necessary for individualized learning
Professional Development	• Occasional individual training, usually offsite	• Provide training according to initiative plans • Provide basic computer skills training (Microsoft Office, etc.)	• Train IT team • Teachers receive computers well in advance of one-to-one • Base instructional competency on instructional goals	• Ongoing professional development for teachers, staff and administrators • Results in increased instructional proficiency • Full instructional integration • Enables systemic change
Resources and Results	• Program created in a vacuum, not looking at other states	• Research other one-to-one programs	• Model policy, funding structures, and infrastructure on other successful programs	• Evaluate and demonstrate success • Data-driven decisions • Become model program

The discussion in Sections 5 and 6 of this literature review, ISTE's essential conditions for technology implementation, and the Centre for Digital Education's Blueprint Components are offered to guide thinking and planning toward one-to-one mobile computing. Regardless of what version of these sets of conditions or components are chosen, the literature recommends that a framework is used to shape the conversation about one-to-one computing early in the planning process.

7. What are the implications of this research for Alberta?

"The best way to predict the future is to create it."

– Peter Drucker

It is clear from the literature that 1:1 mobile computing is not merely a fad that is on the rise – it has many real benefits for teaching and learning that warrant further investigation. But what are implications of this research for Alberta?

Alberta is well positioned to engage in one-to-one mobile computing investigations.

- The province has high speed capacity via the SuperNet, access to curriculum-correlated multimedia resources via LearnAlberta.ca, a positive working relationship with stakeholders regarding technology research initiatives, and substantial expertise with the province's school divisions.
- The *Alberta Education Business Plan (2006-2009)* goals and strategies support further research into promising practices in the use of technology in schools (see http://www.education.gov.ab.ca/department/businessplan/bp2006-09.pdf).
- Alberta has a policy framework that supports learning and technology (see the *Learning and Technology Policy Framework* at http://www.education.gov.ab.ca/reading/policy/techframework/LTfwrk.pdf).
- Alberta's Commission on Learning recommends that ongoing research be done to assess the effectiveness of new approaches using technology to improve teaching and learning (see recommendations 61 to 68 at http://www.education.gov.ab.ca/commission/PDF/CommissionReport.pdf). .

In this fertile environment, a systematic longitudinal study of one-to-one mobile computing could be undertaken using a research community of practice model similar to that currently being used to support video-conferencing research in Alberta. The investigations could address research questions such as:

1. *In what ways can one-to-one mobile computing* ***enhance learning*** *for students, teachers, and the community?*
2. *What are the merits and best practices of using one-to-one mobile computing to facilitate innovation in* ***professional practice****?*
3. *In what ways can one-to-one mobile computing support the acquisition of* ***21st Century skills*** *for students and teachers?*
4. *What are the* ***technical merits and best practices*** *of using one-to-one mobile computing to facilitate teaching and learning?*

Further investigations could help extend the body of knowledge about one-to-one mobile computing and inform related activities in Alberta.

The investigations could also examine those areas identified by Anne Davies[113] as requiring further study, including the need to learn more about the effects of one-to-one mobile computing:

- on different kinds of learners,
- in different kinds of learning contexts,
- on assessment that supports learning and communicates success,
- on evaluation and meeting accountability demands, and,

[113] Davies, Anne; "*Finding Proof of Learning in a One-to-One Computing Classroom*"; April 2004, Connections Publishing; p. 106

- on how to support students, teachers, and other people to learn and be supported in their work in this new environment.

These investigations could help to extend the body of knowledge about one-to-one mobile computing and inform related activities in Alberta.

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